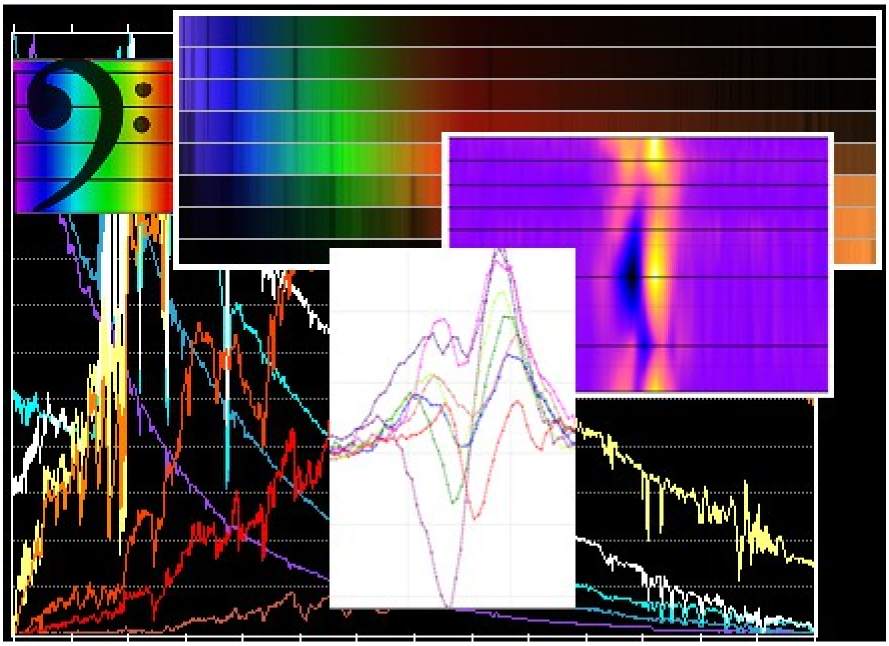
BASS Project User Guide

Basic Astronomical Spectroscopy Software



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Contents

1 BASS Project User Guide

1.1 Introduction

BASS Project is a Windows based application for amateur astronomical spectroscopy. The application was designed with new users in mind and is able to perform all of the standard spectroscopic processing tasks (e.g. calibration, instrument correction, continuum removal, background subtraction etc.) with relatively few steps and without the need to save intermediate files.

BASS Project provides a rich set of tools for spectral profile processing and presentation of single or multiple spectra. It also provides image processing functions to crop and correct for rotation, tilt, smile and slant distortions for FITS and RGB (e.g. bitmap, jpeg & png) image formats. RGB files are automatically imported into a FITS format which makes it easy for new users to get started using a DSLR or web cam. Various text format profiles, such as DAT or UVES are also fully supported. In addition, tabular TFITS files can also be loaded.

With image stacking and functionality to submit to BeSS and other online databases provided, BASS Project can be considered to be a fully comprehensive 'one stop shop' for all your pre-processing and data reduction needs.

A BASS 'project' consists of one or more spectral images and their associated profiles, to which reference spectra, Planck temperature curves, element lines, and annotation labels can be presented.

For details of historical changes made to BASS Project see Appendix D – Amendment History

There is a Yahoo group at http://uk.groups.yahoo.com/group/astrobodger for users to access downloads, post their work and ask for help.

1.2 Installation

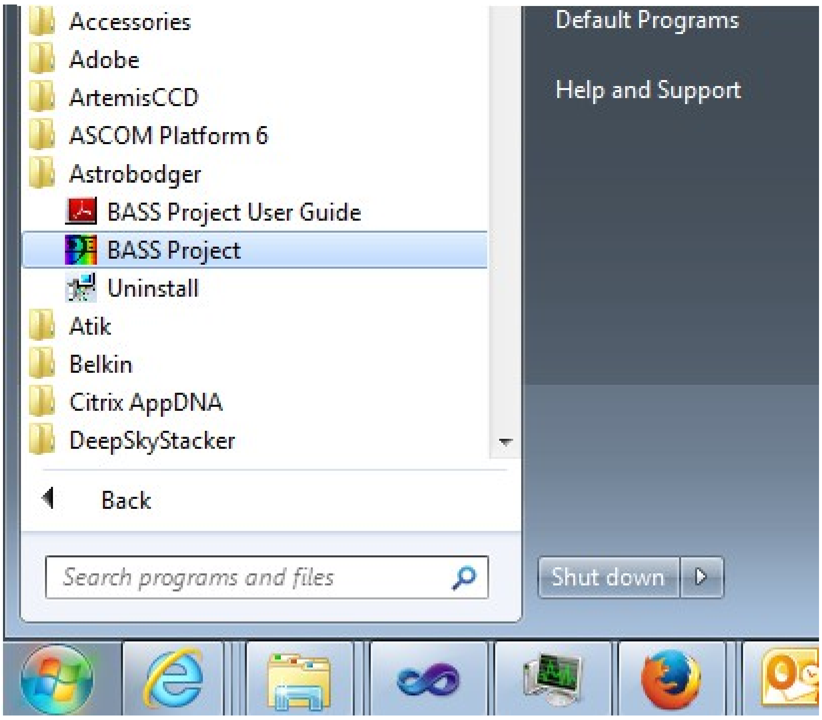
BASS Project is a .NET application that should run on Windows XP, Windows 7, Windows 8 or Windows 10 (32 or 64bit) PCs.

Download the latest MSI setup & installation package from the BASS Project downloads section of the following link:
https://uk.groups.yahoo.com/neo/groups/astrobodger/links/all

Save the MSI file to a temporary location and then run accepting the default options.

Microsoft .NET 4 is the only prerequisite required; this is normally already provided on most PCs. If not, the installer will prompt for it to be downloaded.

To minimise issues to do with Windows 7(and above) access permissions, the default installation path is C:\Astrobodger\BASS Project. If this is changed to be *under "C:\ Program Files\" then it may be necessary to provide administrative access and or set compatibility to XP.*



Installation will create a Start Programs group that contains links to the user guide and the link to Uninstall.

The MSI will install the 32-bit version of the application, BASSProject.exe. Users on 64-bit windows can optionally download and install the 64-bit version.

Check if there are patch release folders having a higher version than the MSI file and follow the release notes to apply updates when required. The release notes may also describe new functionality that has not yet been included in this user guide.

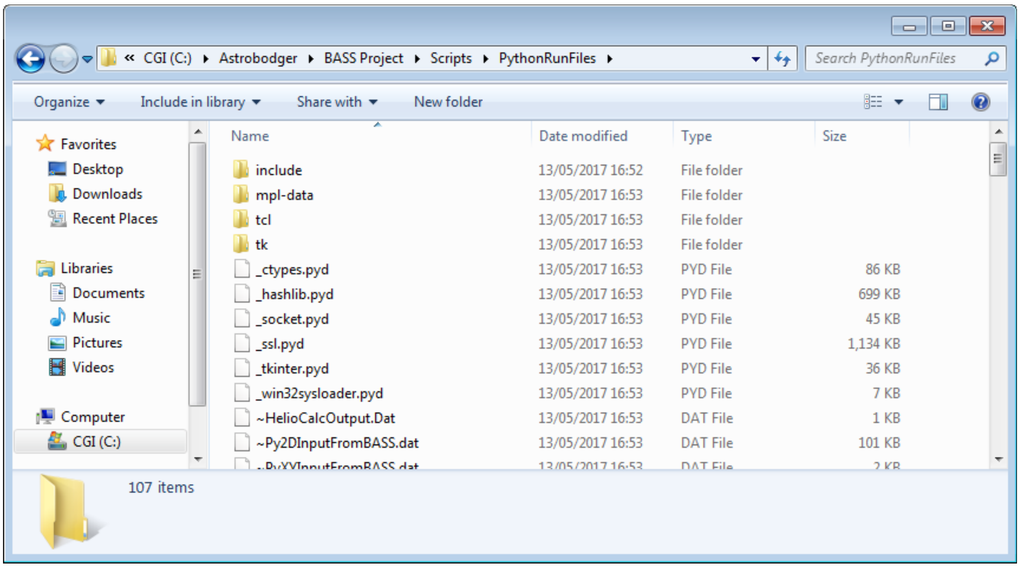
There are some additional components below that are not included with the MSI installer.

1.2.1 PythonRunFiles

The PythonRunFiles zip folder contains advanced tools such as 3D plots and barycentric velocity calculations.

Download the zip from:
https://www.dropbox.com/s/l9bo0fywonbckez/PythonRunFiles.zip?dl=0

Extract the contents of the PythonRunFiles in the zip file into your C:\Astrobodger\BASS Project\Scripts\PythonRunFiles folder as per screenshot below.



Name	Date modified	Type	Size
include	13/05/2017 16:52	File folder	
mpl-data	13/05/2017 16:53	File folder	
tcl	13/05/2017 16:53	File folder	
tk	13/05/2017 16:53	File folder	
_ctypes.pyd	13/05/2017 16:53	PYD File	86 KB
_hashlib.pyd	13/05/2017 16:53	PYD File	699 KB
_socket.pyd	13/05/2017 16:53	PYD File	45 KB
_ssl.pyd	13/05/2017 16:53	PYD File	1,134 KB
_tkinter.pyd	13/05/2017 16:53	PYD File	36 KB
_win32sysloader.pyd	13/05/2017 16:53	PYD File	7 KB
~HelioCalcOutput.Dat	13/05/2017 16:53	DAT File	1 KB
~Py2DInputFromBASS.dat	13/05/2017 16:53	DAT File	101 KB
~PyXYInputFromBASS.dat	13/05/2017 16:53	DAT File	2 KB

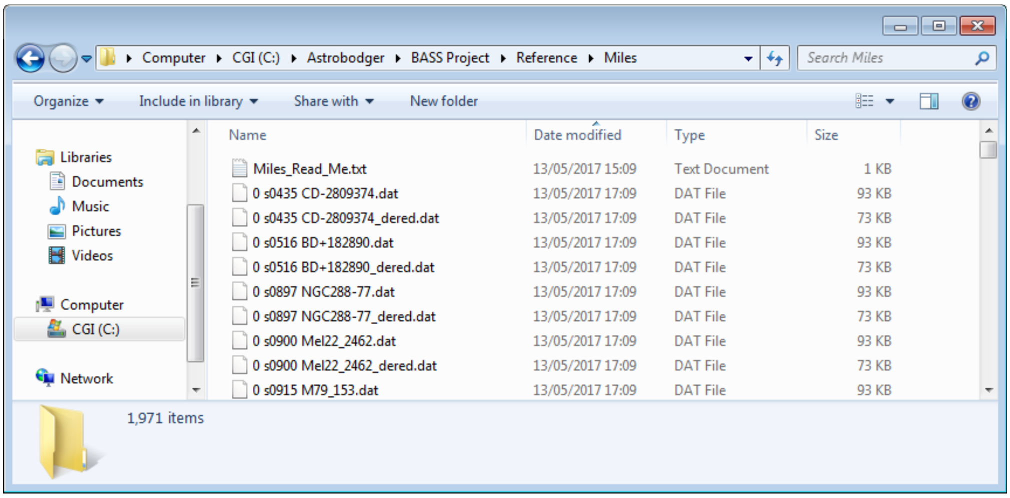
For clarification – you don’t need to install the Python language. The zip file includes compiled executables and run time dependencies.

1.2.2 Miles reference library

The Miles reference spectra library can be used as a higher resolution alternative to the Pickles reference spectra that are provided with the BASS Project MSI installer.

Download the Miles library zip from:
https://www.dropbox.com/s/oqk4omkrjpslopl/MilesLibraryBASS.zip?dl=0

Extract the zip contents into the C:\Astrobodger\BASS Project\Reference\Miles folder as per screenshot below.

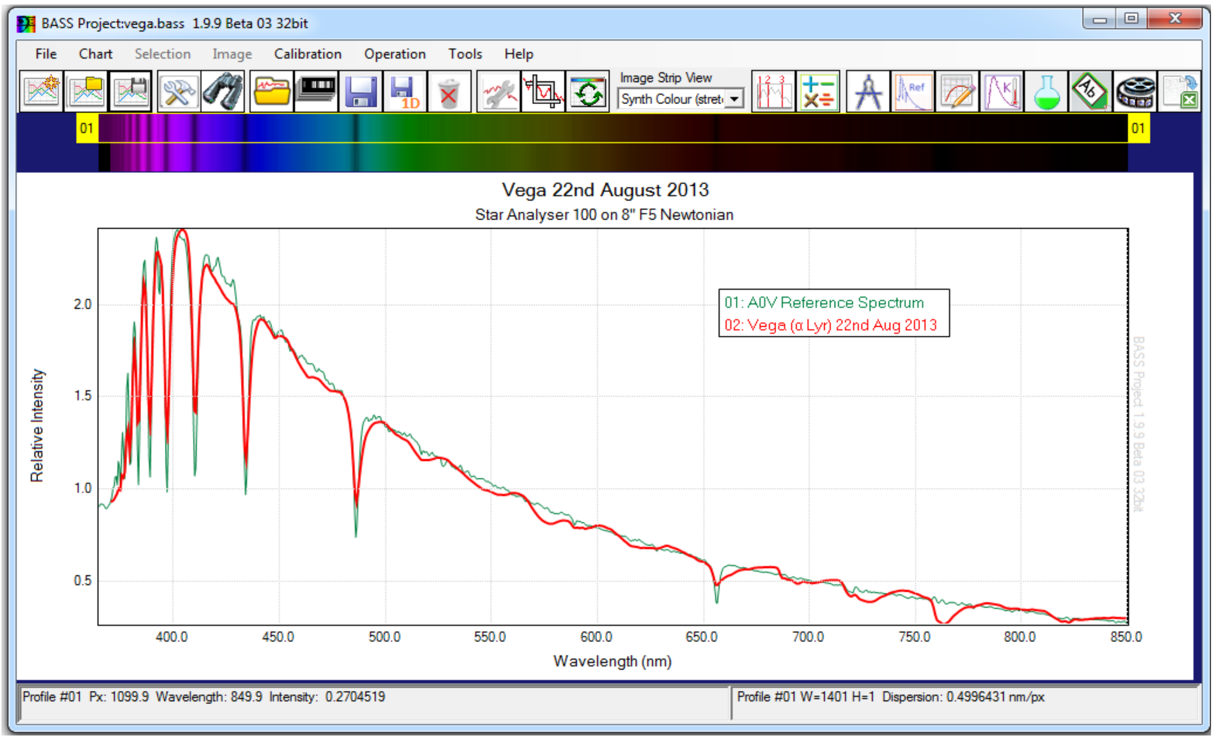


Name	Date modified	Type	Size
Miles_Read_Me.txt	13/05/2017 15:09	Text Document	1 KB
0 s0435 CD-2809374.dat	13/05/2017 17:09	DAT File	93 KB
0 s0435 CD-2809374_dered.dat	13/05/2017 17:09	DAT File	73 KB
0 s0516 BD+182890.dat	13/05/2017 17:09	DAT File	93 KB
0 s0516 BD+182890_dered.dat	13/05/2017 17:09	DAT File	73 KB
0 s0897 NGC288-77.dat	13/05/2017 17:09	DAT File	93 KB
0 s0897 NGC288-77_dered.dat	13/05/2017 17:09	DAT File	73 KB
0 s0900 Mel22_2462.dat	13/05/2017 17:09	DAT File	93 KB
0 s0900 Mel22_2462_dered.dat	13/05/2017 17:09	DAT File	73 KB
0 s0915 M79_153.dat	13/05/2017 17:09	DAT File	93 KB

2 Functionality

BASS Project uses a single main screen interface with additional pop-up forms displayed as required. Functionality is available via traditional menus, the main toolbar and context sensitive “right mouse click” menus.

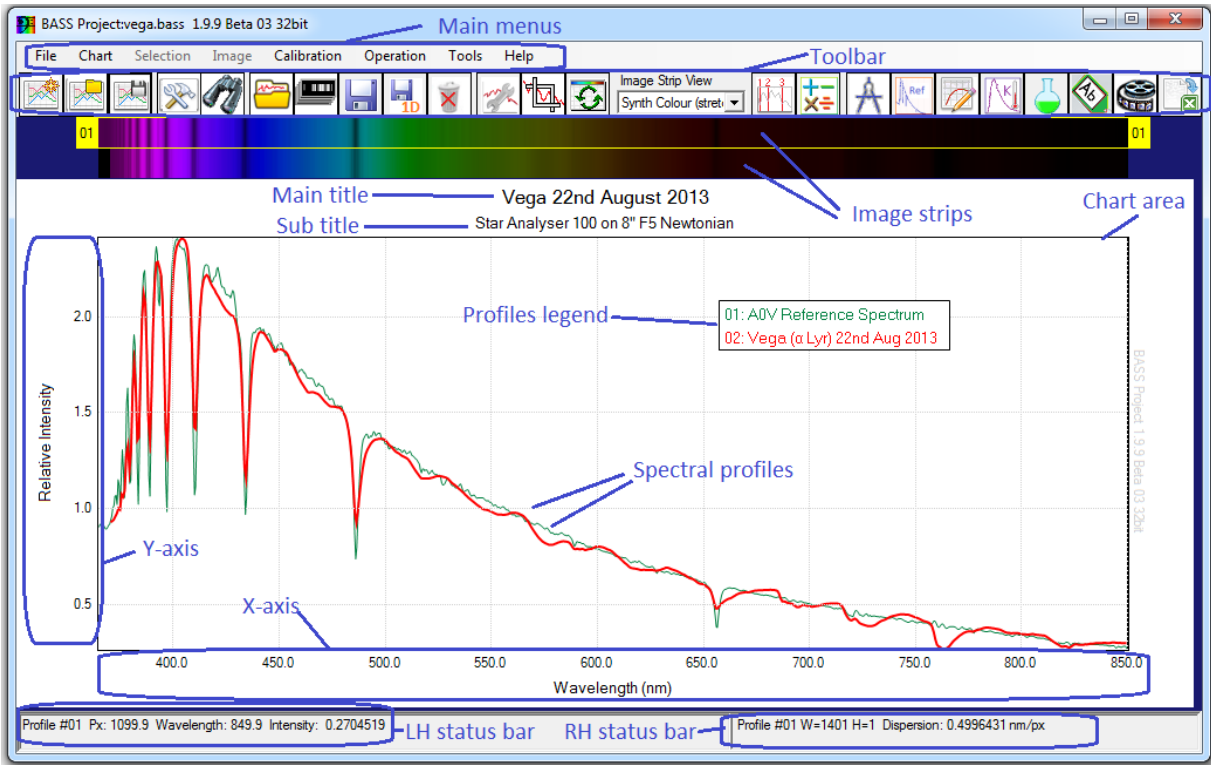
Most of the icons, controls and buttons incorporate a short ‘tool tip’ description when hovered over. The main screen loaded with an example project is shown below.



Profile #01 Px: 1099.9 Wavelength: 849.9 Intensity: 0.2704519

Profile #01 W=1401 H=1 Dispersion: 0.4996431 nm/px

The screen is divided up into sections shown in the diagram below.



Profile #01 Px: 1099.9 Wavelength: 849.9 Intensity: 0.2704519

Profile #01 W=1401 H=1 Dispersion: 0.4996431 nm/px

One or more spectral images (in FITS, RGB or DAT formats) can be loaded at any time. When an image is loaded, it is presented (as either a raw image or binned view) in an image strip under the toolbar. The spectral profile associated with the image is then plotted in the chart area. Clicking on one of the image strips will make it active.

The display of an image as a raw image or binned view is determined by the Image Strip view drop down list selection (in the centre of the toolbar) and is detailed in its own section later.

The ‘active’ image strip is shown highlighted with a yellow border that also shows the sequence number starting from 1. The majority of popup forms (e.g. Rotation, Image Resize, Measurements) act upon the active image selected and many have an option to apply changes, such as geometric corrections consistently to all the loaded images.

The first profile (sequence =1) has special significance since it determines the x-axis pixel or wavelength range, the y-axis scaling and calibration status of the chart. Where displayed, the y-axis values are based on the first profile. By default, subsequent profiles are automatically scaled to fit the chart, however, scaling options can also be manually configured.

The LH status bar shows pixel, wavelength (if calibrated) and profile intensity information for the active image corresponding to the position of the mouse.

The RH status bar shows the image size and dispersion (if calibrated) of the active image. A one dimensional profile will show height H=1.

The chart area shows profiles associated with loaded images. The derivation of a one dimensional profile from a two dimensional image is detailed later.

2.1 Menu and toolbar function

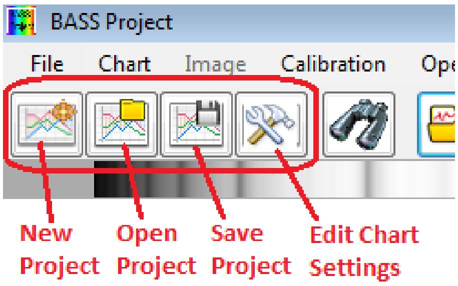
The menu and toolbar functions are grouped info functional areas

2.1.1 Project File Functions

A BASS Project is saved as a (*.bass) text file that contains the following:

- Chart settings (e.g. wavelength unit, title, colours, fonts, x and y axis settings)
- Links to one or more spectral profiles using absolute paths.
- Spectral profile settings (calibration options, instrument correction options, scaling, displayed caption, active & background regions, colour & style)
- Links to one or more reference spectra and settings (caption, colour & style)
- Planck temperature curves and settings
- Element labels and annotation settings.

The project function icons allow projects to be opened, and saved.



The New, Open & Save project functions are also available via the File menu.

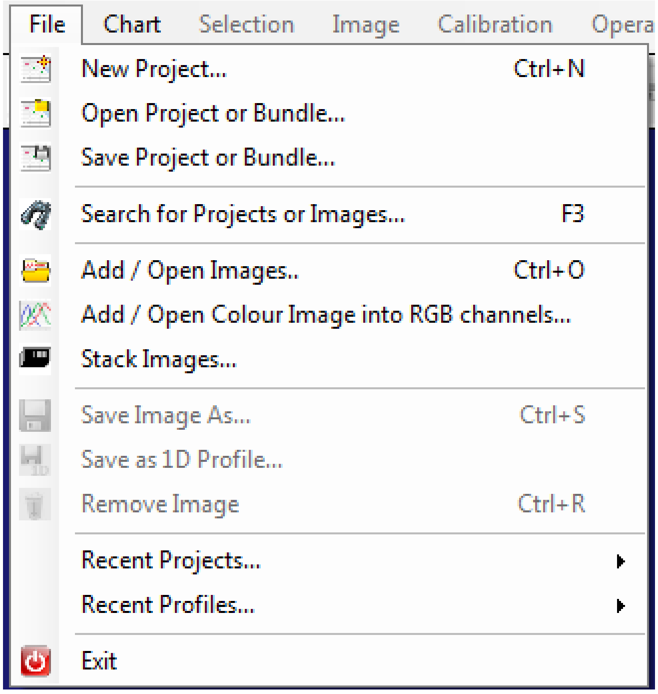
Edit Chart (project) settings are under the Chart menu. Chart settings are described in their own section.

2.1.2 File menu

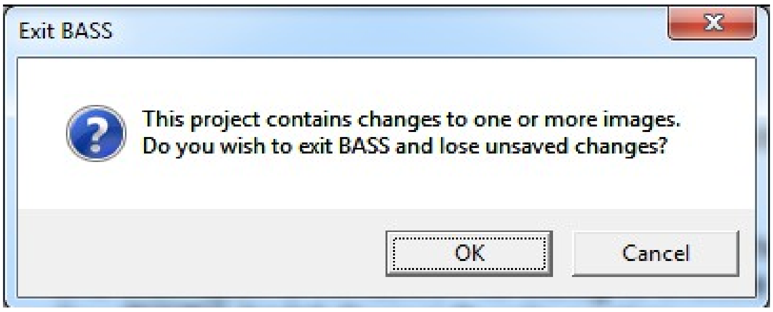
The File menu items provide an alternative means to access toolbar functions for projects or image files. Many of the more commonly used functions are available from the toolbar or have short cut key strokes. For example Ctrl+O will open images.

Menu items will be enabled or disabled according to context, e.g. Save Image is disabled if there are no images loaded.

When starting out, a new user will typically open and save images before they move onto using projects.



New Project - Will start a new empty project with default project options. Will prompt in case there are unsaved changes to images.


Exit BASS

This project contains changes to one or more images.
Do you wish to exit BASS and lose unsaved changes?

Open Project or Bundle – Will prompt in case there are unsaved changes to images and then open a Windows File dialog to choose a Project (*.bass) or Bundle (&.bun). See 2.1.2.1 BASS Project Bundle section.

Save Project or Bundle - Will prompt in case there are unsaved changes to images and then open a Windows File dialog to save a Project (*.bass) or Bundle (&.bun). See 2.1.2.1 BASS Project Bundle section.

Note: There is no separate Save Project function without a file dialog. Just overwrite your file.

Search for Projects or Images – See 2.1.5

Add/Open Images - Will open a Windows File dialog for a user to select one or multiple images to load.

Add/Open Colour Image to RGB channels - Will open a Windows File dialog to select a single RGB (bmp, png, jpg) file to load as separate red, green and blue channels.

Stack Images – Combine and/or process multiple images. See 2.8

Save Image As – Opens Windows File dialog to saves the selected image to disc.

Note: There is no separate Save function without a file dialog. Just overwrite your file.

Save AS 1D Profile – Converts a two dimensional image to a one dimensional profile.

Remove Image – Removes selected file. User is prompted for unsaved changes.

Recent Projects – Provides quick access to the last 20 projects loaded

Recent Profiles – Provides quick access to the last 20 images loaded

Exit - Will prompt in case there are unsaved changes before closing the application.

The Profile Functions section 2.1.6 provides more details on using project and image files.

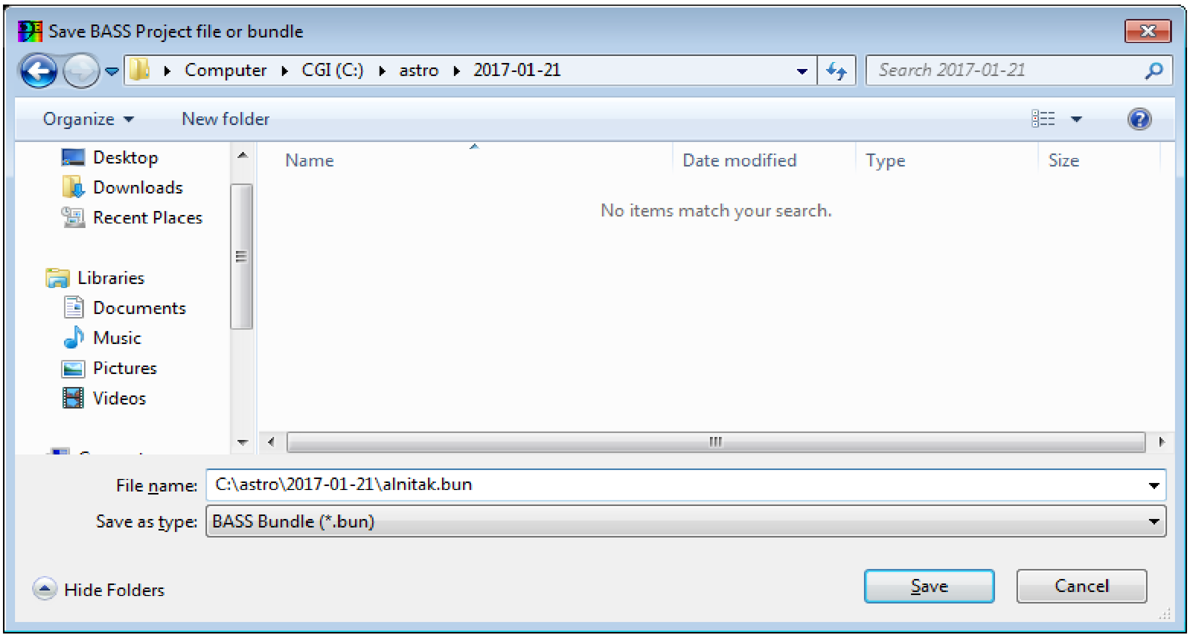
2.1.2.1 BASS Project bundle

A bundle file (*.bun) is proprietary binary format that contains all profiles and settings associated with a project as a single file. This is the recommended way to share BASS projects with other users.

Saving a bundle

The save project file dialog includes a Save as "bundle" type drop down option. It is recommended you first save the project normally with a .bass extension before saving as a bundle.

Browse to set the filename and path and then use the Save as type drop down to select the 'BASS Bundle (&.bun)' option. Make sure the file extension is also changed to .bun.



No items match your search.

File name: C:\astro\2017-01-21\alnitak.bun

Save as type: BASS Bundle (*.bun)

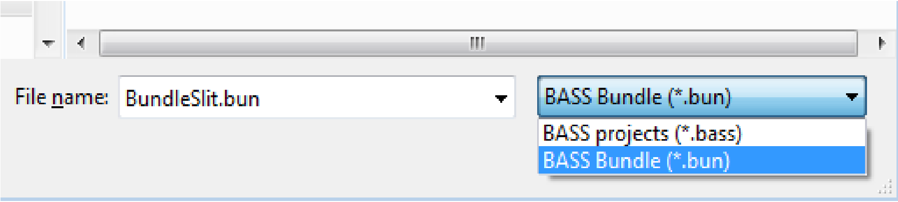
This will save the project, each profile + info.bas file, labels, etc. into a single file that you can send to or share with another BASS user.

Note: It is recommended that you test the bundle you have created will open correctly before sending it out.

Opening a bundle

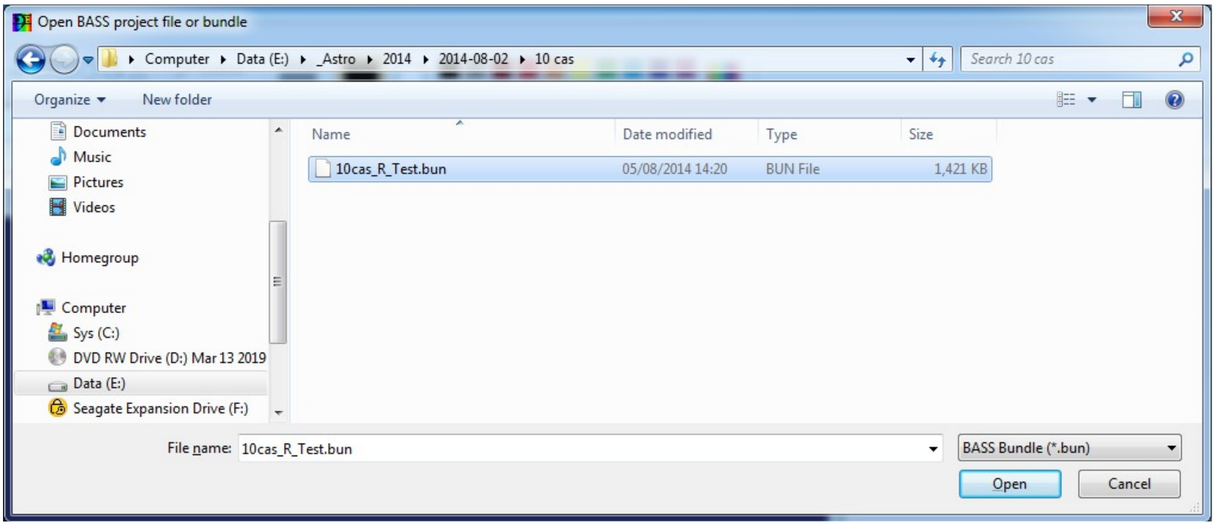
Click on the Open Project menu from the File menu (or toolbar icon) to show the Open BASS Project file dialog.

Select the BASS Bundle from the drop down list on bottom RH corner.


File name: BundleSlit.bun

BASS Bundle (*.bun)

Browse to find your bundle file and click OK.



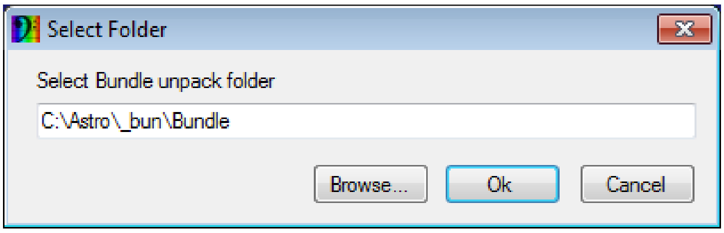
Name	Date modified	Type	Size
10cas_R_Test.bun	05/08/2014 14:20	BUN File	1,421 KB

File name: 10cas_R_Test.bun

BASS Bundle (*.bun)

This opens a Select Folder dialog that prompts for a folder to unpack the files into.

The default is a sub folder having the name of the bun file.



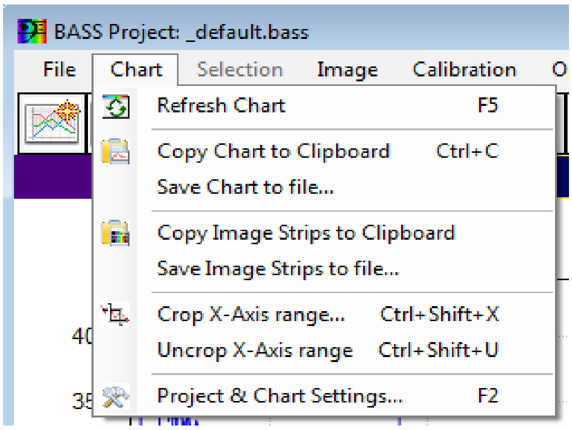
Select Bundle unpack folder

C:\Astro_bun\Bundle

The application then loads the unpacked BASS file complete with profiles settings etc.

2.1.3 Chart Menu

The Chart menu provides access to the functions below



- Refresh Chart – redraws the chart. Also accessible via the F5 key.

- Copy Chart to clipboard - copies the chart to the Windows clipboard for pasting into another application.

- Save Chart to file – Saves the chart to an RGB picture file.

- Copy Image Strips to clipboard – Copies all the image strips as a single picture. This avoids having the yellow border visible (if you took a screenshot) and allows a picture larger than the screen size to be captured.

- Save Image Strips to file - Saves all the image strips as a single RGB picture. (See Copy Image Strips to clipboard above)

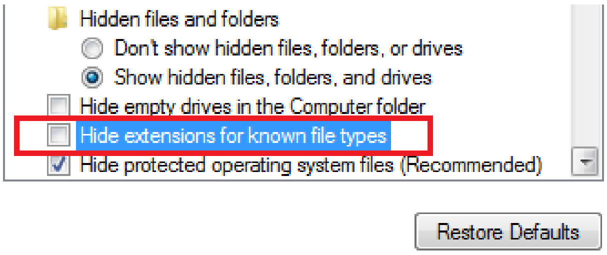
- Crop X-Axis range – Opens screen to selects all or a subset of the x-axis. Detailed in the Crop X-Axis Range section later on.

- Uncrop X-Axis range – Disables cropping to show full wavelength or pixel range of top profile. This function is also available on the X-Axis crop screen.

- Edit Project Chart Settings – Opens the Chart settings screen. Detailed in its own section later on.

2.1.4 BASS file extensions used

BASS uses a few proprietary file extensions. You may need to modify your Windows Explorer settings in order to show file extensions. Go to ‘Tools’ -> ‘Folder Options’ -> ‘View’ and make sure ‘Hide extensions for known file types’ is unchecked.



Hidden files and folders
○ Don't show hidden files, folders, or drives
● Show hidden files, folders, and drives
☐ Hide empty drives in the Computer folder
☐ Hide extensions for known file types
☑ Hide protected operating system files (Recommended)

2.1.4.1 BASS Project file

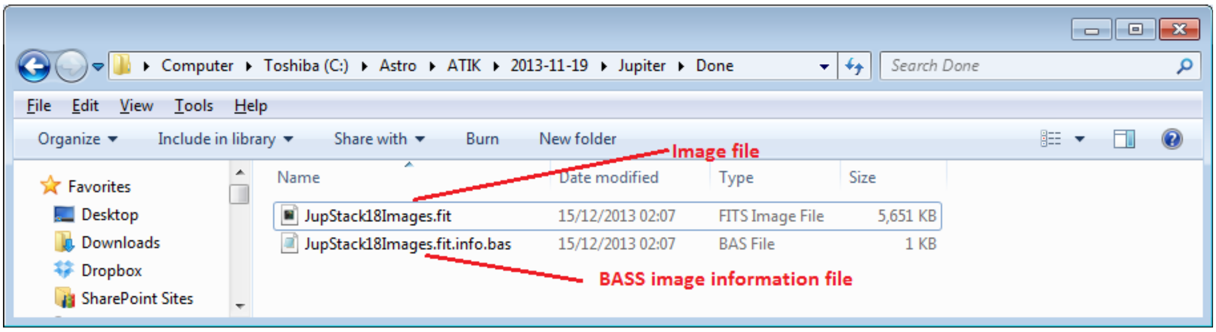
A project file is a text file that uses a four letter extension (*.bass). See Project File Functions section. This file should not be confused with profile information “.info.bas” files that hold calibration and other data per image.

2.1.4.2 BASS Bundle file

A bundle file is a binary file that uses a three letter extension (*.bun). See BASS Project bundle section

2.1.4.3 Profile information file

This is a text file that uses a *.info.bas file extension. BASS automatically creates and manages a small text file alongside every image file. The file is used to hold image specific information such as calibration coefficients and points, response corrections, region selections etc. that are not contained in a FITS header.

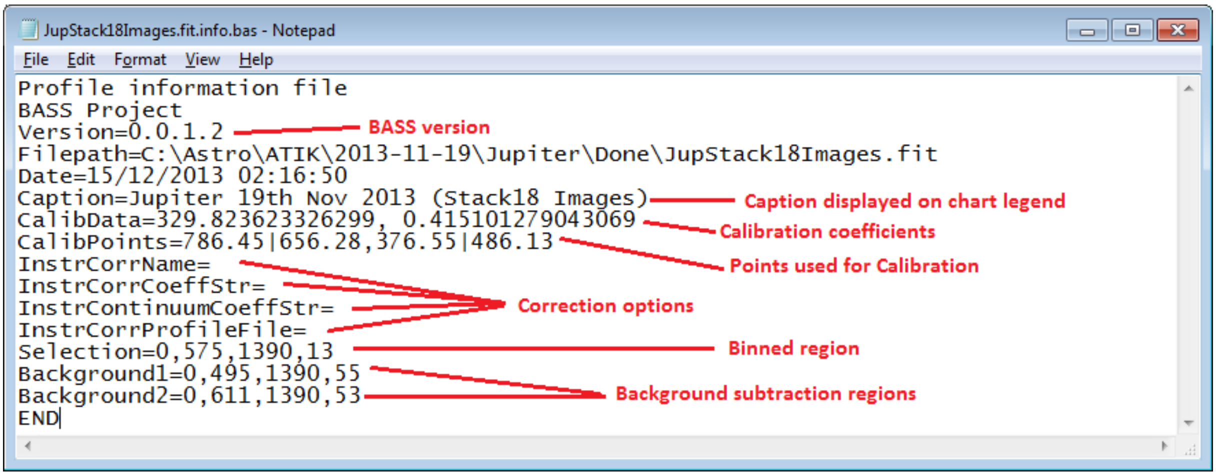


Name	Date modified	Type	Size
JupStack18Images.fit	15/12/2013 02:07	FITS Image File	5,651 KB
JupStack18Images.fit.info.bas	15/12/2013 02:07	BAS File	1 KB

Image file

BASS image information file

Annotated example content of a BASS image information file



```
Profile information file
BASS Project
Version=0.0.1.2
Filepath=C:\Astro\ATIK\2013-11-19\Jupiter\Done\JupStack18Images.fit
Date=15/12/2013 02:16:50
Caption=Jupiter 19th Nov 2013 (Stack18 Images)
CalibData=329.823623326299, 0.415101279043069
CalibPoints=786.45|656.28,376.55|486.13
InstrCorrName=
InstrCorrCoeffStr=
InstrContinuumCoeffStr=
InstrCorrProfileFile=
Selection=0,575,1390,13
Background1=0,495,1390,55
Background2=0,611,1390,53
END
```

BASS version

Caption displayed on chart legend

Calibration coefficients

Points used for Calibration

Correction options

Binned region

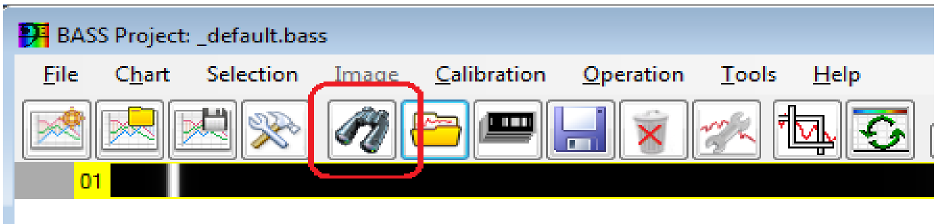
Background subtraction regions

When sending/sharing BASS images to other BASS users, be sure to include the BASS profile information files (.info.bas) located in the same folder as your actual image files. Alternatively, it will be much easier to save the project as a single BASS bundle (*.bun) file that can be emailed or shared using Dropbox or similar.*

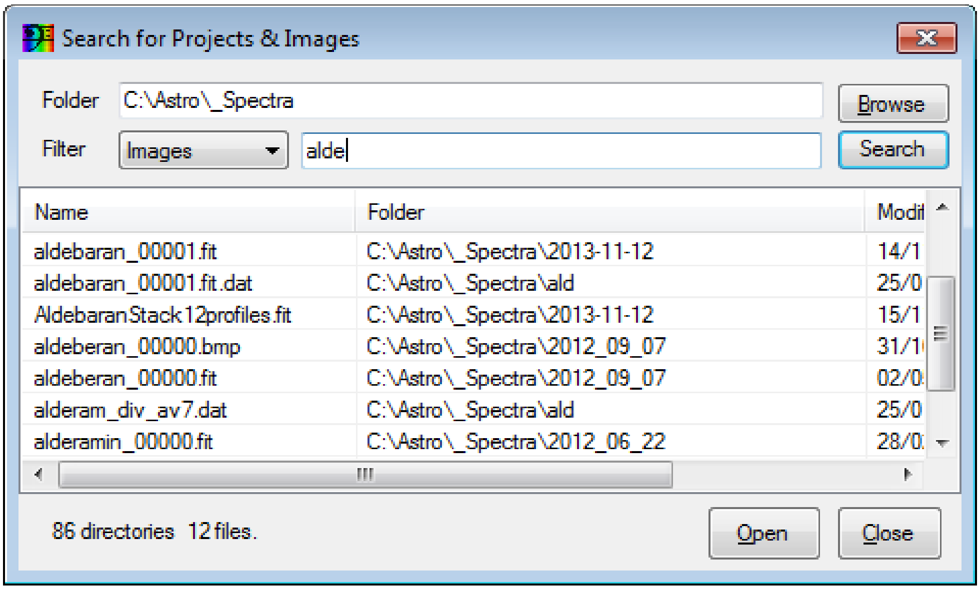
2.1.4.4 BASS Label set

This is a *.lbl text file that contains label rendering information. See Labels Screen

2.1.5 Search function



The Binocular icon opens the modal Search screen. (Also available under File menu)



Folder C:\Astro_Spectra

Filter Images alde

Name	Folder	Modi
aldebaran_00001.fit	C:\Astro_Spectra\2013-11-12	14/1
aldebaran_00001.fit.dat	C:\Astro_Spectra\ald	25/0
AldebaranStack12profiles.fit	C:\Astro_Spectra\2013-11-12	15/1
aldeberan_00000.bmp	C:\Astro_Spectra\2012_09_07	31/1
aldeberan_00000.fit	C:\Astro_Spectra\2012_09_07	02/0
alderam_div_av7.dat	C:\Astro_Spectra\ald	25/0
alderamin_00000.fit	C:\Astro_Spectra\2012_06_22	28/0

86 directories 12 files.

This will search for images (in DAT, RGB & FITS formats) or complete projects (*.BASS) files depending on the “Filter” drop down list.

The “Folder” textbox contains the folder to search under (including sub folders). The Search button will look under the specified “Folder” to match text entered in the filter textbox, (including * wildcard). A blank filter textbox returns all files. The results are shown in the grid underneath.

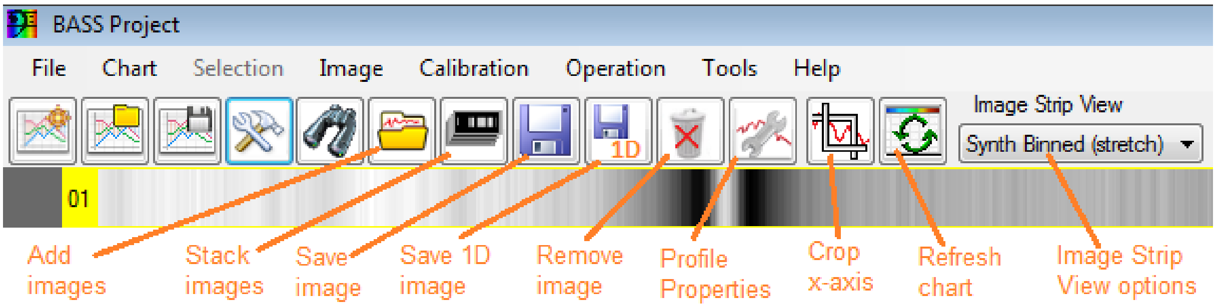
One or more profiles can be selected. Clicking Open will add the selected images to the project (& display them in the chart). The same images can be added more than once (in order to simultaneously display corrected and uncorrected views of a profile).

For projects, only one project can be selected. Clicking Open will close any existing images and load the selected project. (Only one project can be open at a time). Press the Close button to access the main screen.

2.1.6 Profile functions

An image having height=1 is technically a one dimensional profile where values from each column have been processed to single values (“binning”). The term “image” is used loosely here. It can refer to a two dimensional image (where conversion to a single dimension is calculated at run time) or a one dimensional image.

The toolbar image and profile functions are shown below



Note: Functionality has increased substantially since the toolbar was created. The Tools menu provides access to a large number of functions that won't fit on the toolbar.

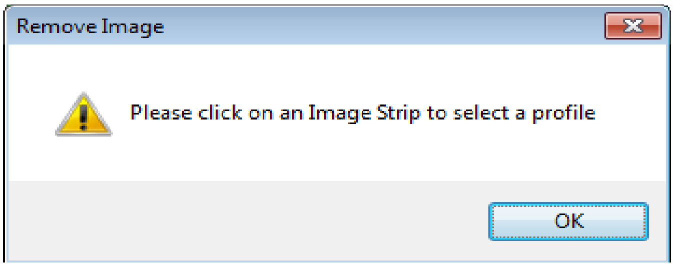
Add Images – the icon allows one or more images to be added to the chart.

Colour RGB (jpg, png, bmp, tif, gif) images will be opened as black and white. The File menu does also provide an option to open an RGB image into separate red, green and blue image channels.

Stack Images – the icon opens up the Stack Images screen which allows a single image to be created from a set of raw images.

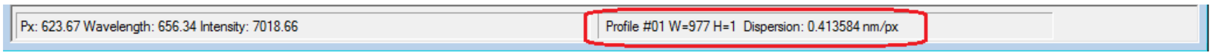
Save Image – the icon allows the selected image to be saved

If no image strip is selected the following message will appear.



Please click on an Image Strip to select a profile

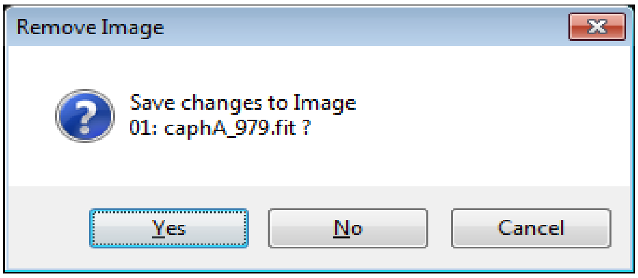
To select an image, just click on the image strip. A yellow border will indicate which image strip is selected (active). The sequence number and dimensions of the selected image strip are displayed on the RH status bar. If the profile is calibrated, the dispersion in wavelength unit per pixel is also displayed.



Px: 623.67 Wavelength: 656.34 Intensity: 7018.66

Profile #01 W=977 H=1 Dispersion: 0.413584 nm/px

Remove Image – the icon prompts to save unsaved changes before removing the current selected image.



Save changes to Image
01: caphA_979.fit ?

The three options are:

- Yes – confirm the filename and save the image. Once saved the image strip is removed
- No – remove the profile without saving changes
- Cancel – abort the profile removal

Note – If the Shift key is held down when a profile is being removed then a prompt to actually delete the file will appear.

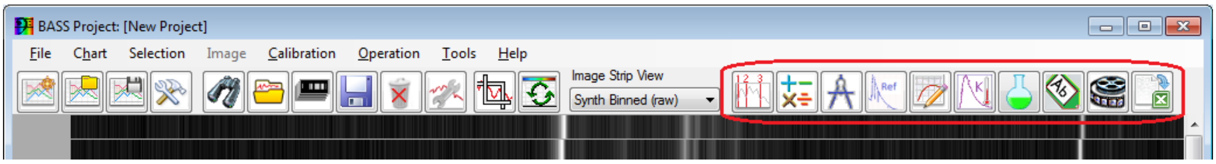
Edit profile settings – the icon opens the Profile Properties screen (described in its own section)

Crop X-axis – this opens the modal Crop X-Axis Range screen to enable you to zoom in on a region of the chart. This is a core feature that is critical to getting the most out of the application.

Refresh Chart – Redraws the chart. The F5 key will also refresh the chart.

Image Strip View – this drop down list allows a choice of how the image list is to be displayed. See the Image Strips section

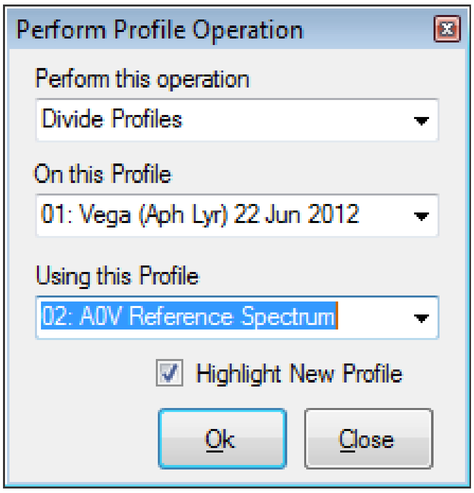
2.1.7 Advanced Tools functions



Calibration – an icon is provided to edit the existing calibration points of the top profile. If the profile is not calibrated then a new calibration is started.

The main Calibration menu is more useful than the toolbar icon since it allows a choice of options, including displaying calibration points on the chart.
See the Wavelength Calibration section 2.12 for details.

Math Operations – an icon is provided to show the Operations screen.



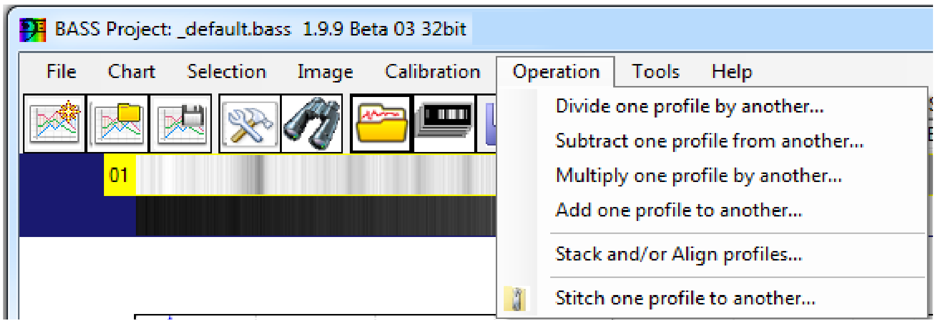
Perform this operation: Divide Profiles

On this Profile: 01: Vega (Aph Lyr) 22 Jun 2012

Using this Profile: 02: A0V Reference Spectrum

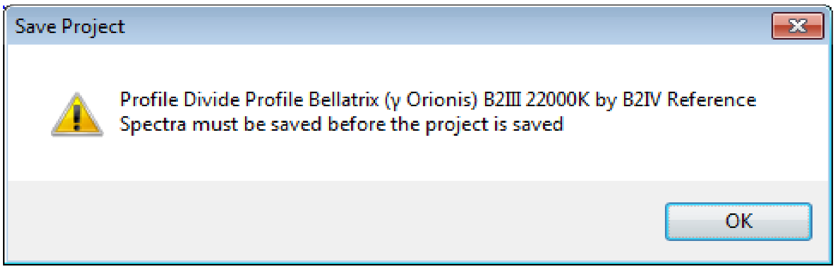
☑ Highlight New Profile

The main Operation file menu includes sub menus for operations plus an option to stack image profiles (of the same width) together to create a new 1-dimensional image. There is also an option to Stitch Profiles together, see Stitch Profiles section.



The result of the operation is displayed in a new image profile (added to the end of the list). The new image can be saved by right clicking on the new image strip and selecting “Save Image As” to invoke the standard File Save dialog.

Note: You will be prompted to save new images created before saving a project.



Profile Divide Profile Bellatrix (γ Orionis) B2III 22000K by B2IV Reference Spectra must be saved before the project is saved

Measurement & Element lines – an icon is provided to access the Measurement & Element lines screen. This allows measurements from the chart to be taken and also allows element lines to be identified, plotted and/or displayed. See Measurements & Elements screen section.

Reference Spectra - an icon is provided to access the Reference Spectra screen. This allows one or more reference spectrum to be added to the chart. See Continuum & Response Shaper section.

Continuum & Response Shaper - an icon is provided to access the Continuum & Response Shaper screen. This allows curves to be created for instrument response correction and/or continuum removal. See Continuum & Response Shaper section.

Planck curves - an icon is provided to access the Planck Curves screen. This allows Planck temperature curves to be added to charts. See Planck Temperature Curve section.

Resample Profile - an icon is provided to access the Resample Profile screen. This allows a profile to be resampled and/or filtered. See Resample Profile section.

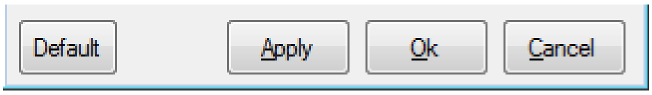
Labels - an icon is provided to access the Labels screen. This allows annotation labels to be added to the chart and managed. See Labels Screen section.

Animation – an icon is provided to access the Animate screen. This allows animations to be created from profiles or saved pictures. See Animation section.

Export Project - an icon is provided to access the Export Project screen. This allows all profiles on the chart to be exported and displayed in a spreadsheet application. See Export Project Data section.

2.2 Chart Settings

The Chart Settings screen allows control of how the chart (project) is displayed. It is organised into separate tabs along the top. This screen is called from various menus and also by double clicking on the chart. The buttons on the base of the screen are common to each tab



Default – A button that stores chart settings to be reused when a new project is started or the application next starts. These settings are held in a file called "_default.bass" located in the application installation folder.

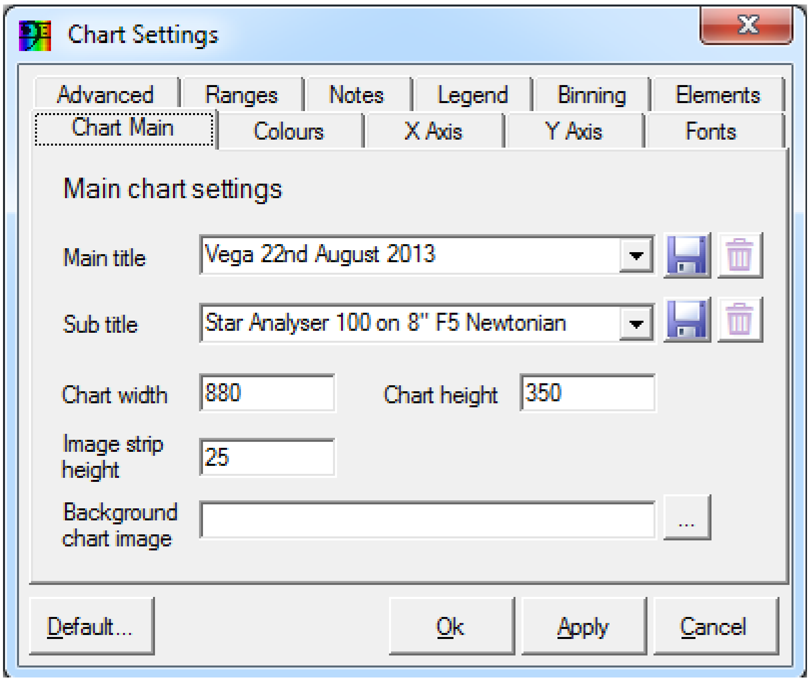
Apply – A button to apply chart setting changes made and keep the screen open.

OK – A button to applies chart setting changes made and close the screen.

Cancel – A button to close the screen.

All chart settings are saved at a project level (i.e. save a project to keep changes).

2.2.1 Chart Main tab



Main chart settings

Main title: Vega 22nd August 2013

Sub title: Star Analyser 100 on 8" F5 Newtonian

Chart width: 880

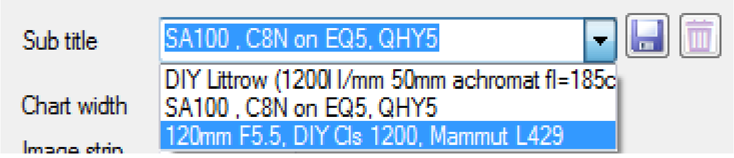
Chart height: 350

Image strip height: 25

Background chart image:

Main Title – text is displayed on the top of the chart area. The adjacent Save and Delete buttons allow titles to be reused (described in Sub Title below)

Sub Title – text to display under the Title. The adjacent Save button allows entries to be saved to the drop down list for reuse. The Delete button will remove a selected item from the drop down list



Sub title: SA100 , C8N on EQ5, QHY5

DIY Littrow (1200l l/mm 50mm achromat fl=185c
SA100 , C8N on EQ5, QHY5
120mm F5.5, DIY Cls 1200, Mammut L429

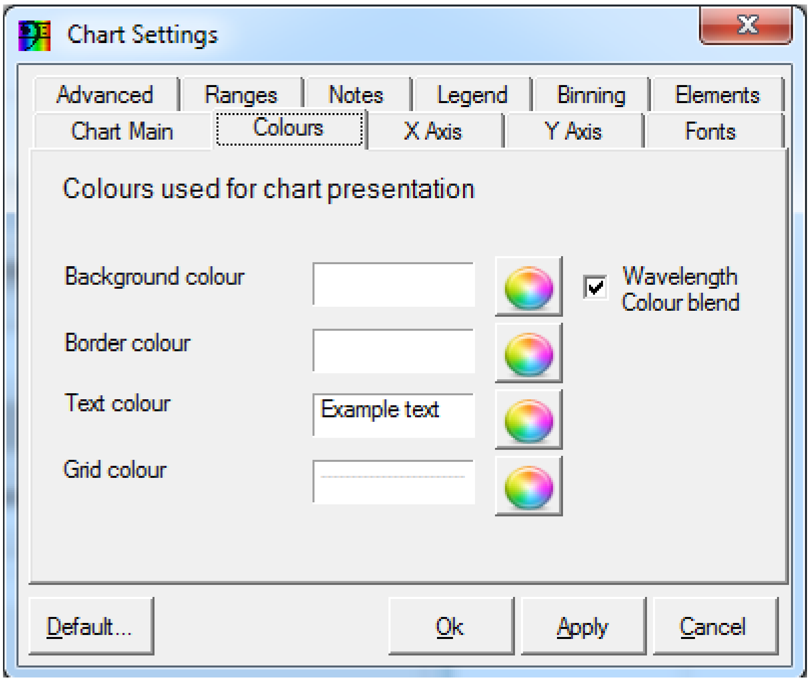
Chart height & width - The width and height of the chart can be set to any sensible value, such as the width of your camera sensor (in pixels). It is can be useful to temporarily set the width to a high value that exceeds the screen width (e.g. 4000) and scroll horizontally to examine features in detail or when calibrating.

Image strip height – Specifies the height in pixels for each of the image strips (when not in one of the raw image strip view options).

Background chart image - Allows a background image file to be displayed in the chart behind the profiles. No scientific value, but you can put a meaningful ‘pretty picture’, perhaps an astronomical photo of your target, as the background

2.2.2 Colours tab

Various colour setting options are provided to personalise your projects.



Colours used for chart presentation

Background colour

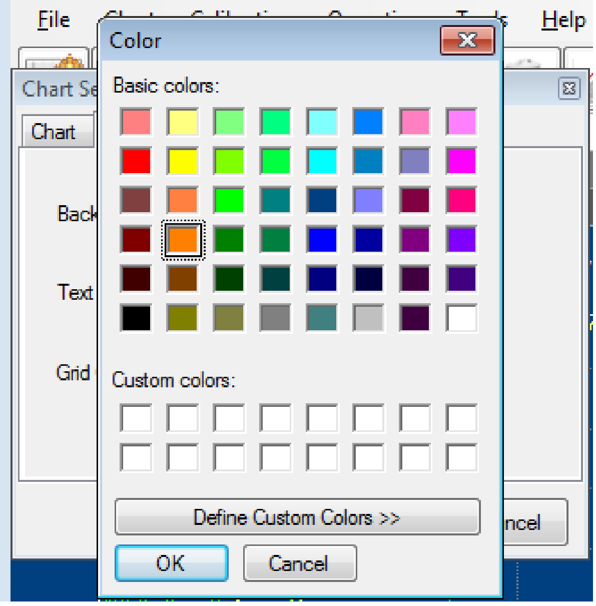
Border colour

Text colour: Example text

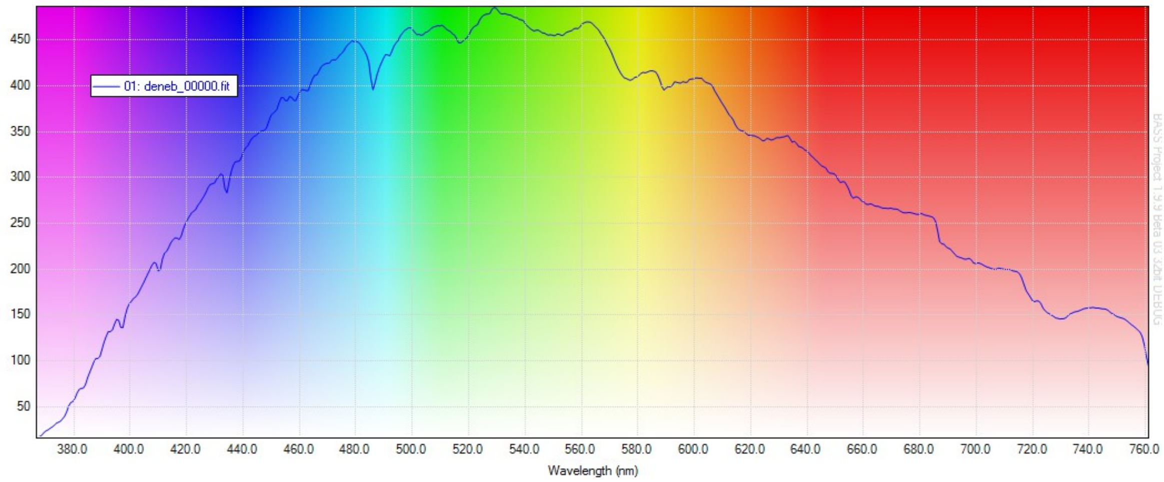
Grid colour

☑ Wavelength Colour blend

Clicking on the coloured icons invoke standard Windows colour selection dialogs.



Wavelength Colour blend – this checkbox will blend the Background Colour with the colour associated with displayed wavelength range, as shown below.



2.2.3 X Axis tab

The X axis tab allows a choice of how the x-axis captions and grid lines are displayed

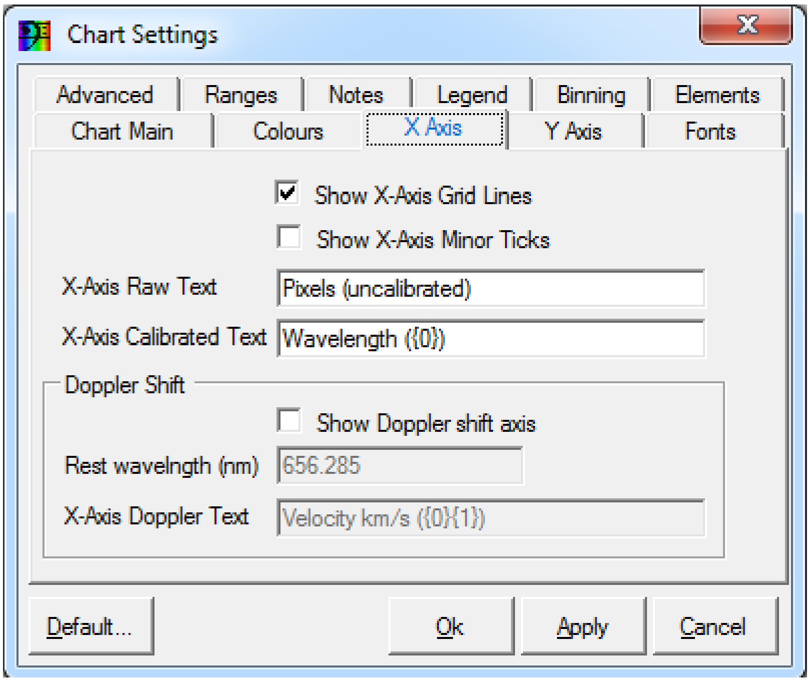
Show X axis gridlines – A checkbox to enable vertical grid lines to be visible

Show X axis Minor Ticks – A checkbox to display minor ticks on x-axis

X axis raw text – A textbox to specify x axis text when the chart is not calibrated

X axis calibrated text – A textbox to specify the x axis text when calibrated. This supports the following place holder parameters

- {0} will display the wavelength unit symbol/abbreviation (Å, nm or µm)
- {1} will display the wavelength unit name (Angstrom, nanometer or micron)



☑ Show X-Axis Grid Lines

☐ Show X-Axis Minor Ticks

X-Axis Raw Text: Pixels (uncalibrated)

X-Axis Calibrated Text: Wavelength ({0})

Doppler Shift

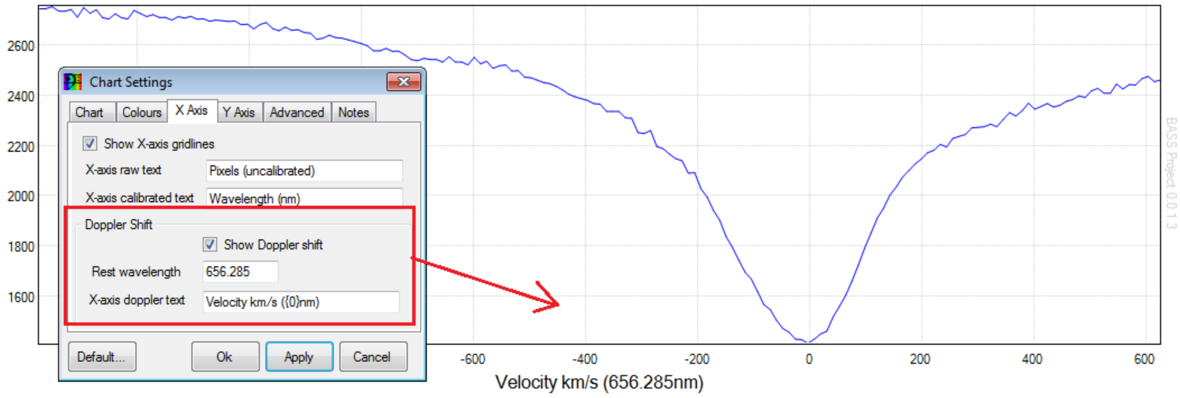
☐ Show Doppler shift axis

Rest wavelngth (nm): 656.285

X-Axis Doppler Text: Velocity km/s ({0}{1})

2.2.3.1 Doppler X Axis

Show Doppler Shift option checkbox - allows velocity (km/s) to be presented on the X axis relative to a stationary wavelength.



☑ Show X-axis gridlines

X-axis raw text: Pixels (uncalibrated)

X-axis calibrated text: Wavelength (nm)

Doppler Shift

☑ Show Doppler shift

Rest wavelength: 656.285

X-axis doppler text: Velocity km/s ({0}nm)

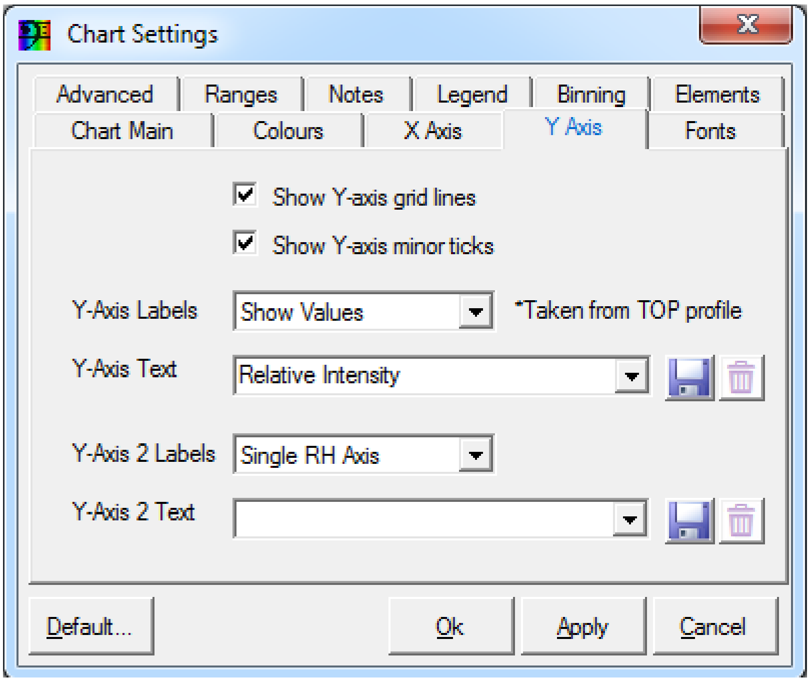
The Measurements screen will include velocity measurements when Doppler X Axis is enabled.

<u>Rest wavelength</u> – specifies the wavelength where velocity=0

<u>X axis Doppler text</u> – the X axis label text displayed when Doppler x axis is enabled. A parameter {0} can be used to show the rest wavelength within the x axis text.

2.2.4 Y Axis tab

The Y axis tab allows a choice of how the y-axis values and grid lines are displayed



☑ Show Y-axis grid lines

☑ Show Y-axis minor ticks

Y-Axis Labels: Show Values *Taken from TOP profile

Y-Axis Text: Relative Intensity

Y-Axis 2 Labels: Single RH Axis

Y-Axis 2 Text:

<u>Show Y axis grid lines</u> – A checkbox to enable horizontal grid lines to be visible

Show Y axis Minor Ticks – A checkbox to display minor ticks on y-axis

Y axis Labels - drop down list allows a choice of two options:

- None – no values are shown on y-axis

- Show Values – Y axis values are shown in ADU (analogue data units) from the top (sequence = 01) image profile.

Y-axis text – drop down list allows a caption, such as ‘Intensity’, to be displayed on the Y axis. The adjacent Save and Dustbin icons allow a list of alternative y axis captions to be managed.

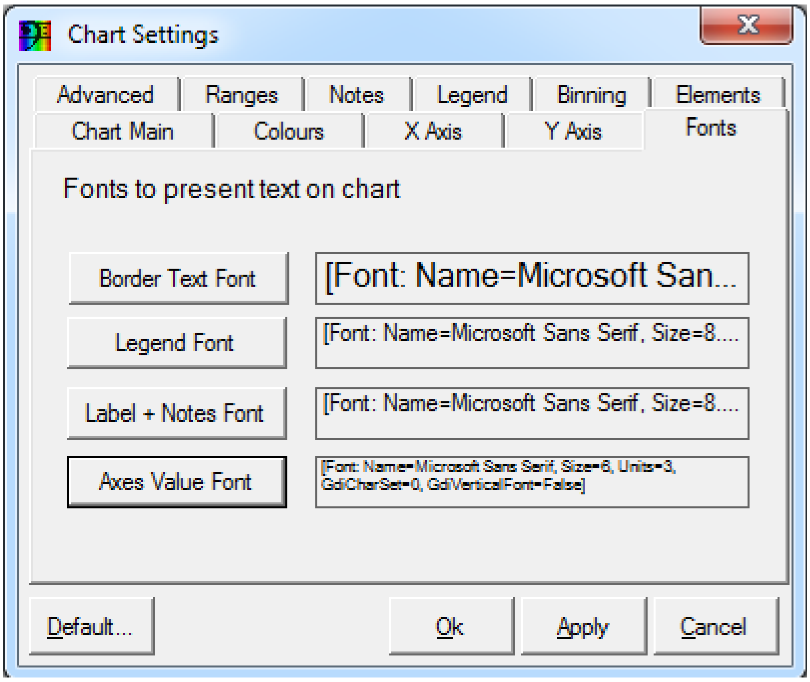
Y-Axis 2 Labels – A drop down list to choose to display options below

- None – no axis to be displayed on RH side of the chart
- Single RH Axis – Display axis in RH margin of the chart. RH axis values are from the profile with sequence number 2
- RH Axis per profile – Display a Y axis for every loaded profile.

Y-axis 2 Text – drop down list containing RH axis text. Multiple text can be managed using the adjacent Save and Dustbin icons.

2.2.5 Fonts tab

The fonts tab allows the font properties of text to be changed



Fonts to present text on chart

Border Text Font [Font: Name=Microsoft San...

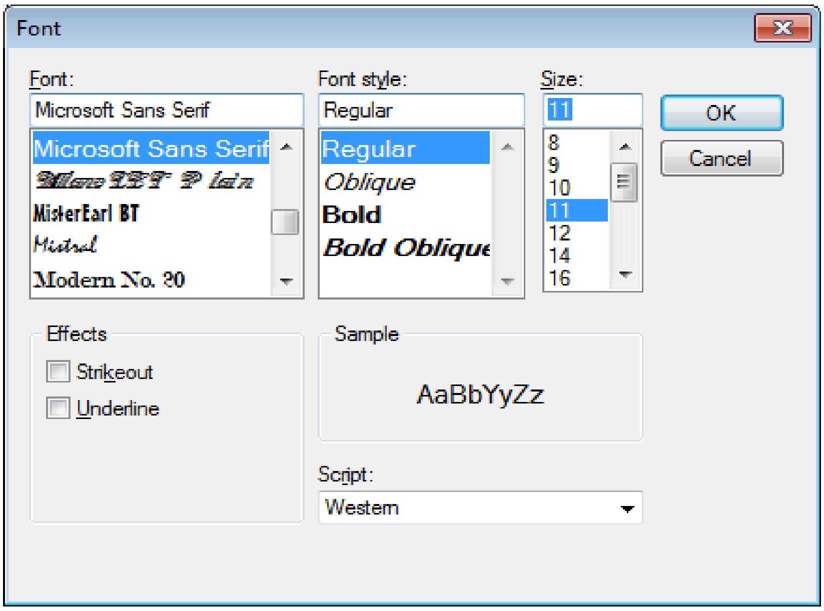
Legend Font [Font: Name=Microsoft Sans Serif, Size=8....

Label + Notes Font [Font: Name=Microsoft Sans Serif, Size=8....

Axes Value Font [Font: Name=Microsoft Sans Serif, Size=6, Units=3, GdiCharSet=0, GdiVerticalFont=False]

Border Text Font – this button opens a font selection dialog to pick the font used to display text on the border area outside the chart. This includes the main title, sub title, y axis caption and x axis caption. This does NOT include the x and y axis values (as they have their own button).

Note that the Main Title font size will be 3 points larger than the value selected.



Font: Microsoft Sans Serif

Font style: Regular

Size: 11

Script: Western

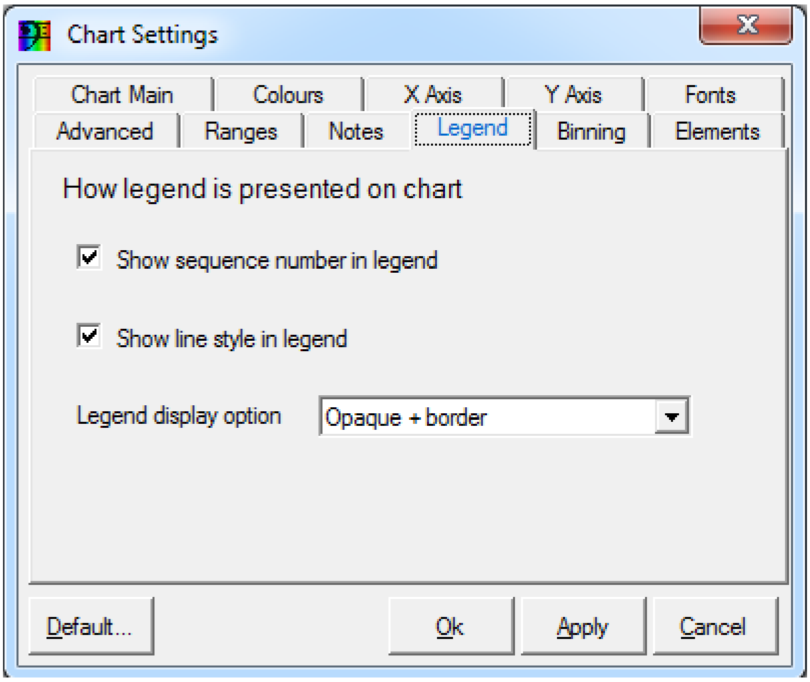
Legend Font – this button opens a font selection dialog to pick the font used to display the captions of loaded profiles in the legend.

Label + Notes Font – this button opens a font selection dialog to pick the font used to display Labels and Notes.

Axes Value Font – this button opens a font selection dialog to pick the font used to display values on the x axis and y axis (if enabled)

Note Stick to common fonts such as Arial or Sans Serif if you plan to share your project with other users. Exotic fonts may be not be installed on other users PCs.

2.2.6 Legend tab



How legend is presented on chart

☑ Show sequence number in legend

☑ Show line style in legend

Legend display option: Opaque + border

The ’Show Sequence in Legend’ checkbox determines if the profile captions listed in the legend are prefixed with the sequence number.

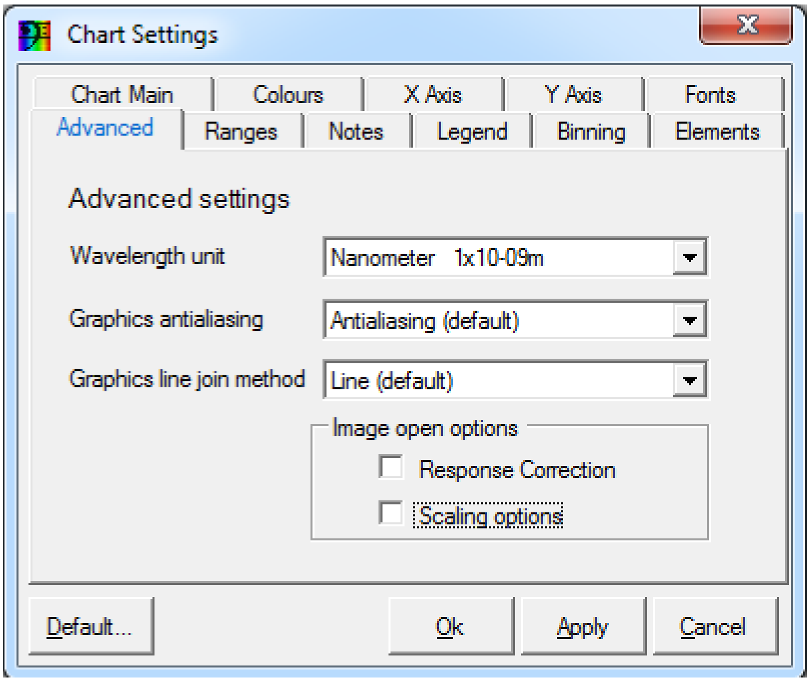
The ‘Show line style in legend’ checkbox will show a section of the line rendered using the line style and marker.

Showing the sequence number or line style will be useful when there are a large number of profiles loaded and you need to know which is which.

Legend Display Option - This allows a choice of how the text is displayed. The options are:

- Transparent text
- Opaque text
- Opaque text + border (this is the default)

2.2.7 Advanced tab



Advanced settings

Wavelength unit: Nanometer 1x10-09m

Graphics antialiasing: Antialiasing (default)

Graphics line join method: Line (default)

Image open options

☐ Response Correction

☐ Scaling options

Wavelength Unit – The drop down list provides a choice of wavelength unit used. The current options are:

- Angstrom 1Å = 1 x 10^{-10} metres
- Nanometer 1nm = 1 x 10^{-9} metres
- Micron 1µm = 1 x 10^{-6} metres

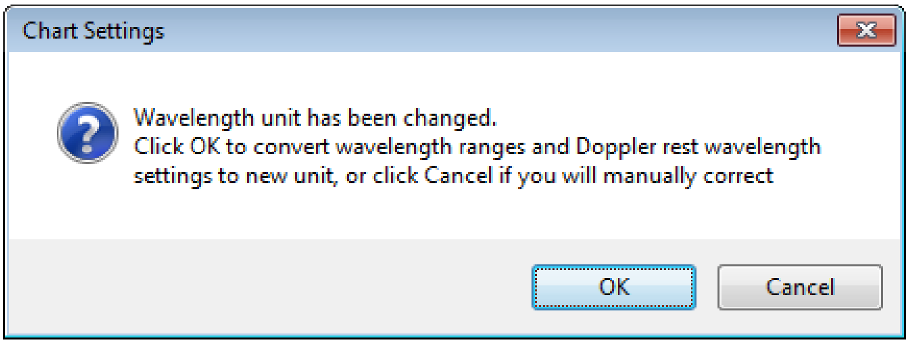
The following settings are sensitive to the wavelength unit so need to be changed along with the unit.

- X-axis Doppler shift rest wavelength

- Processing range

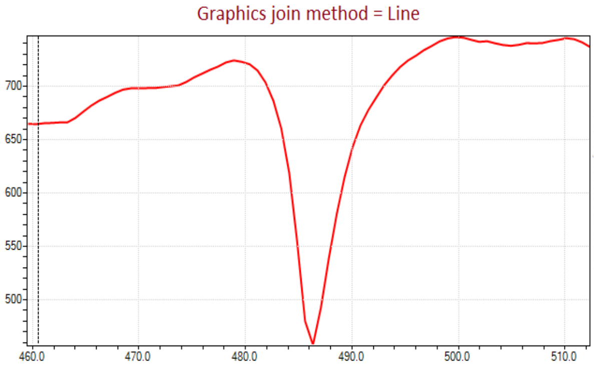
- Continuum range used for flux normalisation to unity
- Sigma value in Elements tab

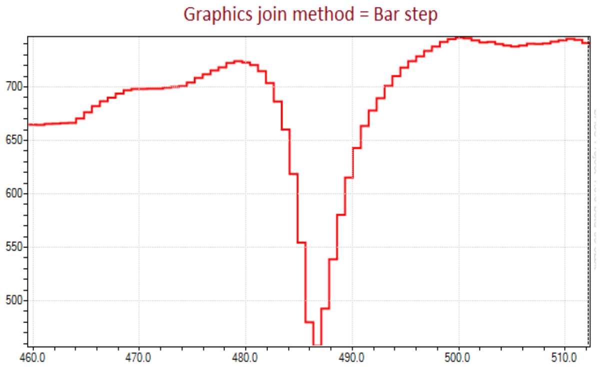
When Apply is pressed and the wavelength unit is changed, a message box will offer a choice to apply an appropriate conversion factor from one unit to another. Click OK if you want the existing values converted, or click Cancel if you will manually corrected the values for the new wavelength unit.



Wavelength unit has been changed.
Click OK to convert wavelength ranges and Doppler rest wavelength settings to new unit, or click Cancel if you will manually correct

Graphics Antialiasing – This option controls how lines in the chart are rendered. The default option is for antialiasing.


Graphics join method = Line

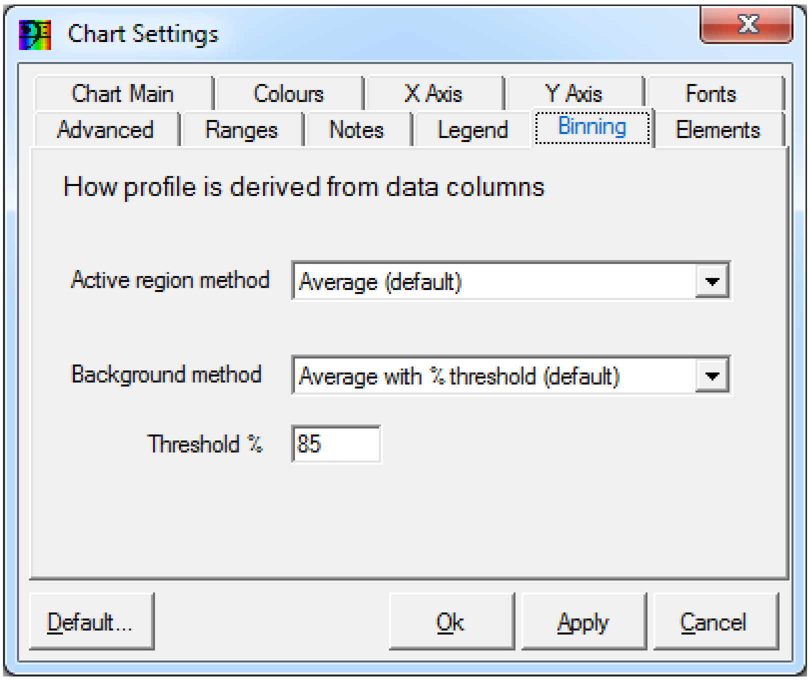

Graphics join method = Bar step

Graphics Line Join method – This option determines how data points are joined up. The default option draws a line between each point. The bar step option draws only horizontal and vertical lines. This option is useful to see any gaps in the data.

Apply Response Correction on image open – When ticked, profiles are rendered with the most recent response setting held in the .info.bas file, otherwise response correction is not applied, (unless applied within a project).

Apply Scaling options on image open – When ticked, the Y-axis scaling option stored in info.bas file is applied. If unticked, automatic scaling is applied, (unless scaling is applied within a project).

2.2.8 Binning tab



How profile is derived from data columns

Active region method: Average (default)

Background method: Average with % threshold (default)

Threshold %: 85

Active region method – The drop down list provides a choice of how intensity is calculated when displaying a profile. The current options are:

- Average – The intensity at a given pixel on the x-axis is the average of values in the y-axis (i.e. each column is averaged). The range of y-axis values summed can be defined using active binned region (otherwise it will average across the height of the image). See the Selection menu.

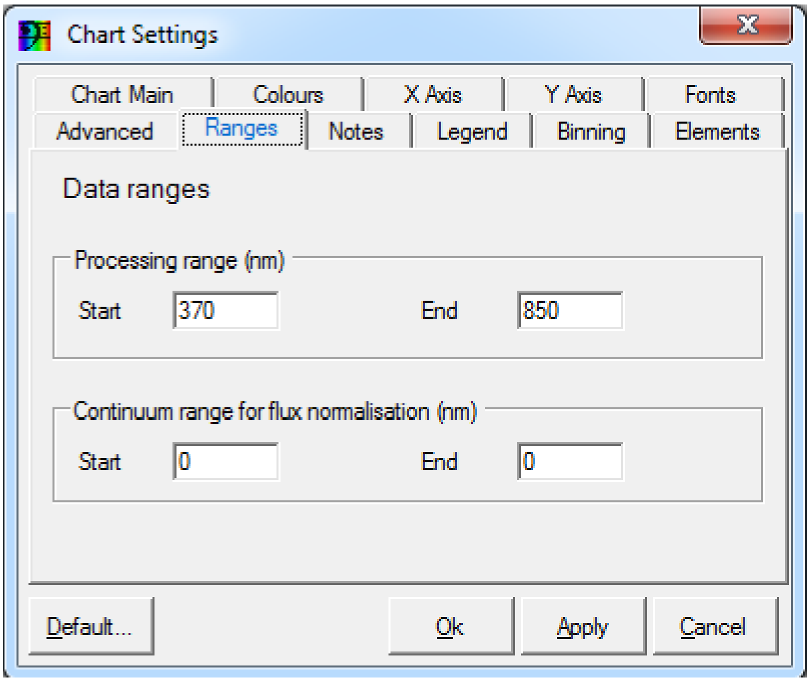
- Exceed Background – Similar to the 'Average' method but only includes values exceeding the average background intensity, assuming a background region has been set.

Background method – The drop down list provides a choice of how background is calculated when displaying a profile. The current options are:

- Average with % threshold
- Exceed Background
- Median

Background threshold % - Percentage used for Background subtraction. Values above the threshold are excluded.

2.2.9 Ranges Tab



Processing range (nm)
Start 370
End 850

Continuum range for flux normalisation (nm)
Start 0
End 0

2.2.9.1 Processing range

The start & end wavelength processing values are used to restrict the range for processing operations such as ‘division’. Without this restriction spurious results where the camera response is low could spoil the results otherwise obtained.

2.2.9.2 Continuum range

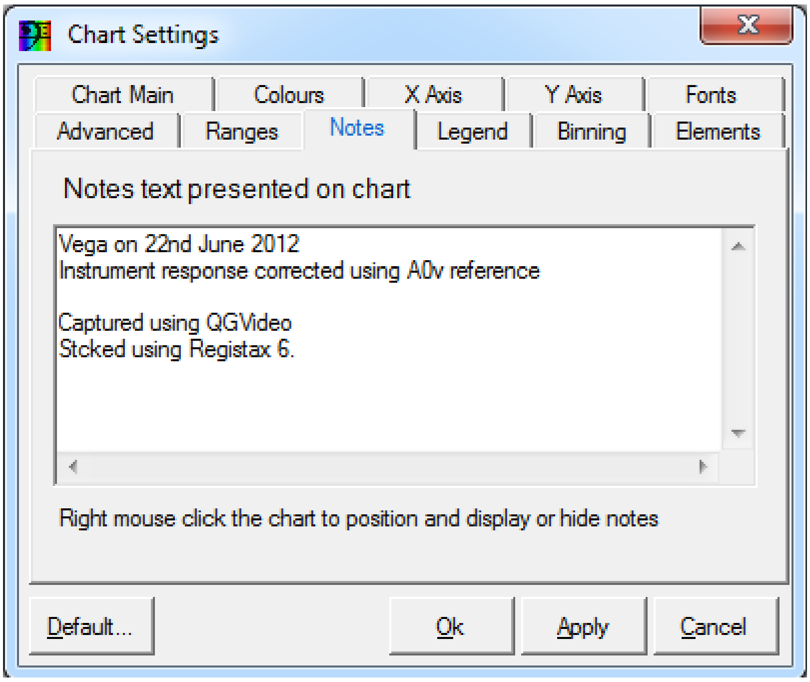
This range is used to provide the default wavelength range for the Flux Normalisation screen.

2.2.10 Notes tab

A multiline textbox allows comments to be held against or displayed on the chart.

The text will be formatted using carriage returns entered into the multiline text box.

Use the chart context sensitive menu (right mouse click on the chart) to display the notes entered on the chart.



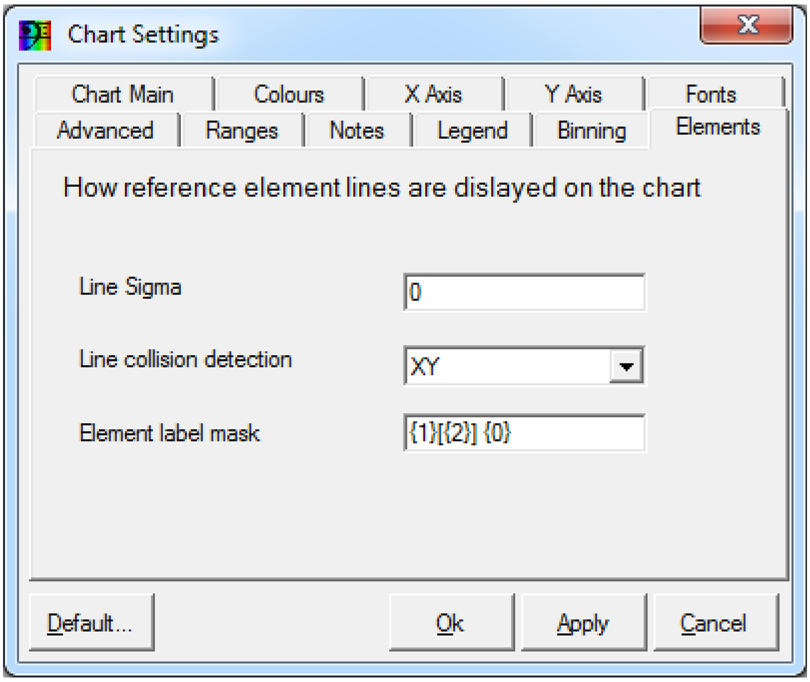
Notes text presented on chart

Vega on 22nd June 2012
Instrument response corrected using A0v reference

Captured using QGVideo
Stcked using Registax 6.

Right mouse click the chart to position and display or hide notes

Elements tab



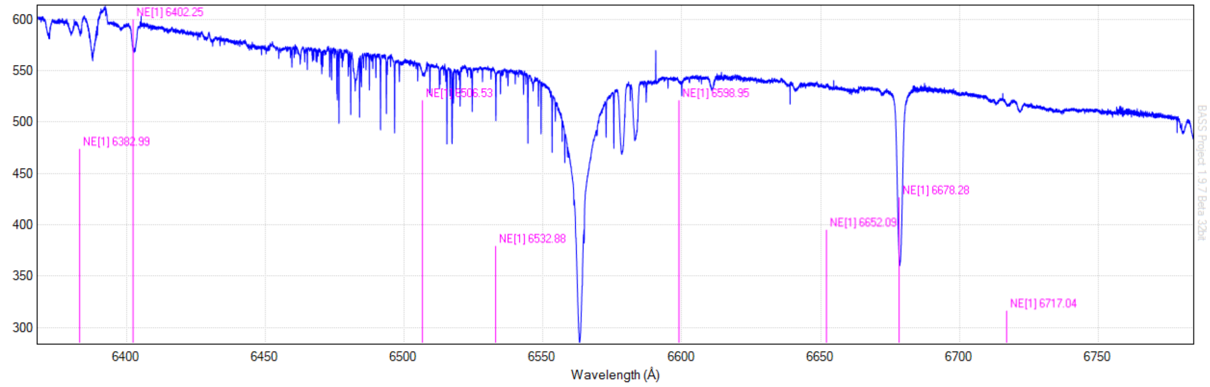
How reference element lines are dislayed on the chart

Line Sigma: 0
Line collision detection: XY
Element label mask: {1}[{2}] {0}

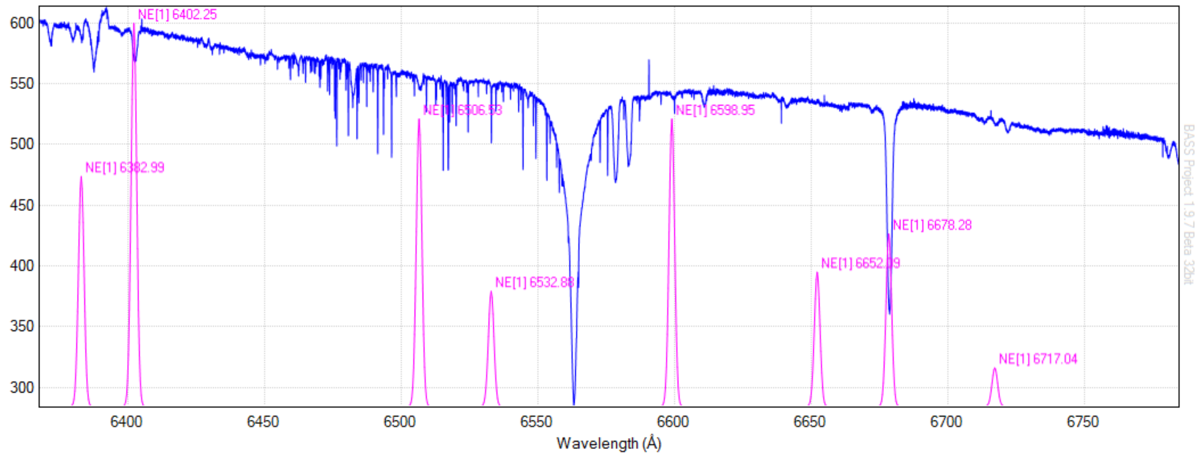
This tab holds the settings that apply to the Scaled Element Lines annotations.

2.2.10.1 Line Sigma

A zero '0' value in this textbox always shows vertical lines when Scaled Element Lines are added to a chart.



A non-zero decimal value draws a Gaussian line having a standard deviation equal to the sigma value in the chosen wavelength unit. Below shows Gaussian lines with sigma =1 Angstrom.



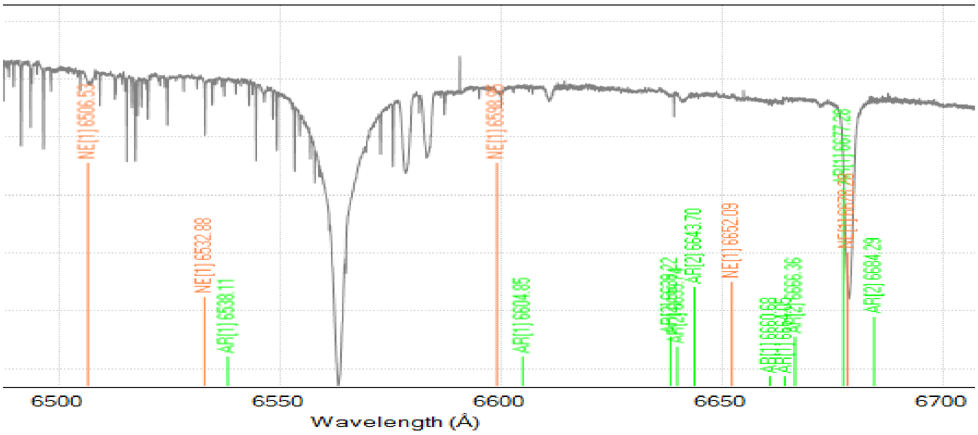
2.2.10.2 Line collision detection

A drop down list is provided to automatically shift Scaled Element Line labels created in the Elements screen where they are congested and overlap.

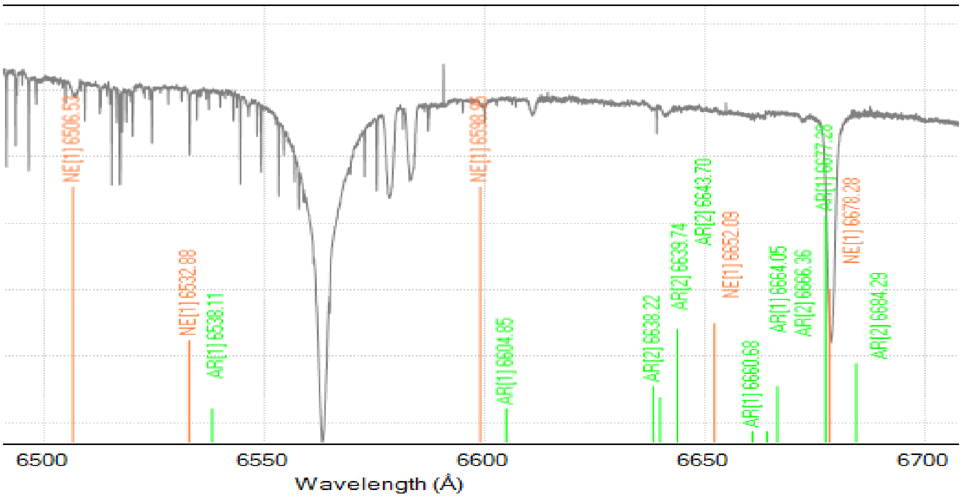
The four options are

- None – No attempt to correct overlapping label text.
- X – Move to right only
- Y – Move up only
- XY – Move right or up

Example below shows congested labels around 6650 Angstroms



The same chart below, but using the 'XY – Move right or up' option

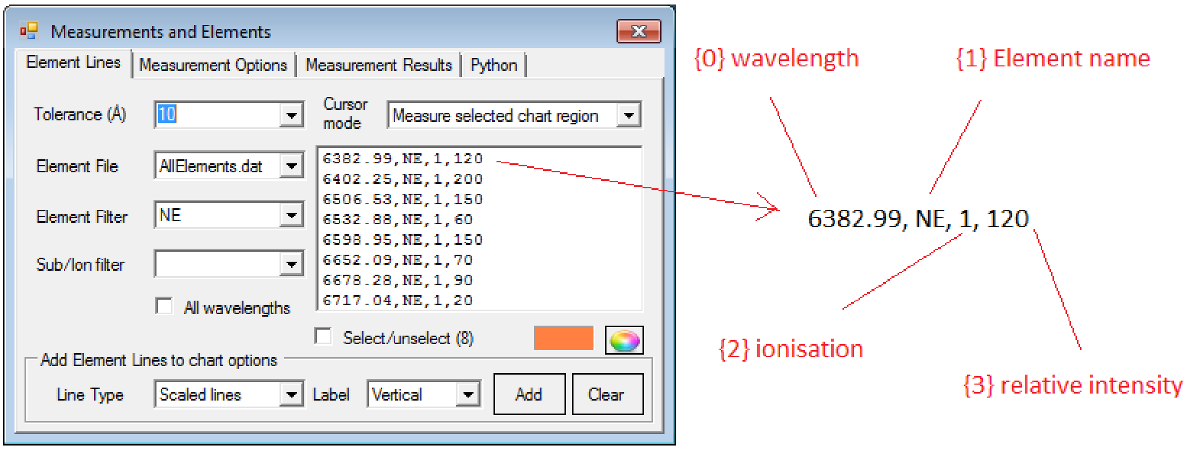


If the congestion is light then manual edit of individual lines can be used to left or right justify text to avoid overlap.

If the congestion is heavy then an alternative is to delete the text associated with overlapping element lines and replace it with a new “Free Line & Label” type labels that allow you to specify exactly there the line and text should be placed.

2.2.10.3 Element Label Mask

This is a free text box allowing configuration of what text is shown after new labels are created from the Elements screen. The mask determines which of the possible placeholders are to be shown.



Tolerance (Å) 10

Cursor mode: Measure selected chart region

Element File: AllElements.dat

Element Filter: NE

Sub/Ion filter:

☐ All wavelengths

```
6382.99,NE,1,120
6402.25,NE,1,200
6506.53,NE,1,150
6532.88,NE,1,60
6598.95,NE,1,150
6652.09,NE,1,70
6678.28,NE,1,90
6717.04,NE,1,20
```

☐ Select/unselect (8)

Line Type: Scaled lines

Label: Vertical

6382.99, NE, 1, 120

{0} wavelength

{1} Element name

{2} ionisation

{3} relative intensity

The mask setting is applied only as new labels are added. It won't affect labels already created.

The data items in a curly brace {} zero based array correspond to the fields shown the list box of the Elements screen above.

The third column {2} is not necessarily ionisation. It depends on the file used.

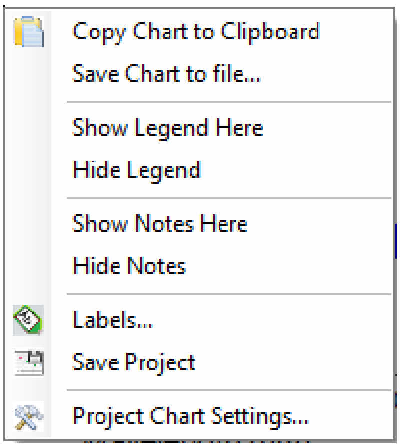
Spaces can be used to separate the fields. Fields can also be separated by line breaks using '\n'.

Some examples (based on using the *AllElements.dat* file in *Reference* sub-folder)

Mask	**Description**	**Label text**
{0}	just show wavelength	6382.99
{1}	just show element name	Ne
{1}[{2}] {0}	show Element name, then ion in brackets then wavelength	Ne[1] 6382.99
{1}[{2}] {0} {3}	show Element name, then ion in brackets, wavelength and relative intensity	Ne[1] 6382.99 120
{1}[{2}]\n{0}	Show Element name, then ion in brackets in first line. Show wavelength on second line. \n indicates a carriage return	Ne[1] 6382.99

2.3 Context Sensitive Chart Menu

Right mouse clicking on the chart area will pop-up the context sensitive chart menu.



- Copy Chart to Clipboard – copies the chart picture to the Windows clipboard for pasting into another application.

- Save Chart to file – allows the chart to be saved as a picture file

- Show Legend Here – Displays the legend showing the list of profiles. The Legend top left corner is displayed at the last position the mouse was clicked.

- Hide Legend – hides the legend from view

- Show Notes Here - Displays the notes keyed into the Project Settings screen. The notes top left corner is displayed at the last position the mouse was clicked.

- Hide Notes – hides the notes from view

- Labels – Opens the Labels Screen to allow features of the chart to be annotated

- Save Project – Prompts user to save project to file.

- Project Chart Settings – open the Chart Settings screen.

2.4 Profile Properties

The profile properties screen allows control of how the profile is displayed. It is organised into separate tabs along the top. This screen is called from context sensitive menus and also by double clicking on an image strip.

The buttons at the base of the screen are visible and apply across all the tabs

Previous button – Navigates to the previous profile (when more than one is loaded)

Save button – this updates the BASS image information file (.info.bas) so changes are reused for other projects using the same profile. (Changes are otherwise only applied to this project).

Remove button – Prompts before removing the current profile (and closes the form)

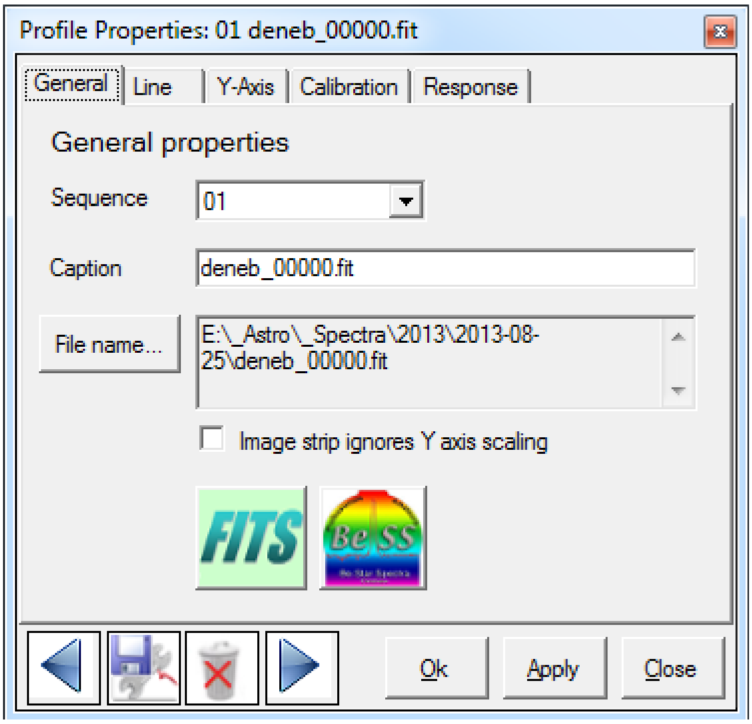
Next button – Navigates to the next profile (when more than one is loaded)

OK button – this applies the profile changes to the project and closes the form

Apply button - this applies the profile changes to the project, but keeps form open

Close button – closes the form

2.4.1 General tab



Profile Properties: 01 deneb_00000.fit

General properties

Sequence: 01

Caption: deneb_00000.fit

File name...: E:_Astro_Spectra\2013\2013-08-25\deneb_00000.fit

☐ Image strip ignores Y axis scaling

The sequence and caption values are saved at a project level (i.e. you need to save the profile in a project). The Caption is also saved at a profile level, in the BASS image information file, (.info.bas) to be the default when opened in other projects)

<u>Sequence drop down list</u> – allows the order that the profiles are displayed to be changed. E.g. setting sequence to “01” will move the associated image strip to the top of the image strip list. This is important since the first profile is used for default y-axis profile scaling and the x-axis span.

<u>Caption textbox</u> – the text entered is displayed in the chart legend. The value initially defaults to the image filename.

<u>Filename textbox</u> – a read only textbox showing where the file is physically located. Use the adjacent File name button to physically rename the file (and its associated info.bas file).

<u>FITS Header button</u> – for FITS images only, the button opens the FITS Header screen. This allows FIT header values to be viewed (and edited).

<u>Image Strip Ignores Y axis scaling</u> – This checkbox prevents the image strip display from brightening or darkening in sync with y axis scaling. This useful when showing profiles above one another while preserving the auto rendered image strip intensities.

In the LH example below, where the setting is turned off on all profiles. The image strip brightness and contrast are proportional to y-axis Scaling% and Offset% applied to the profiles within the chart.

In the RH example below, where the setting is turned **on**, the image strip brightness and contrast are not affected when y-axis Scaling% and Offset% are changed.

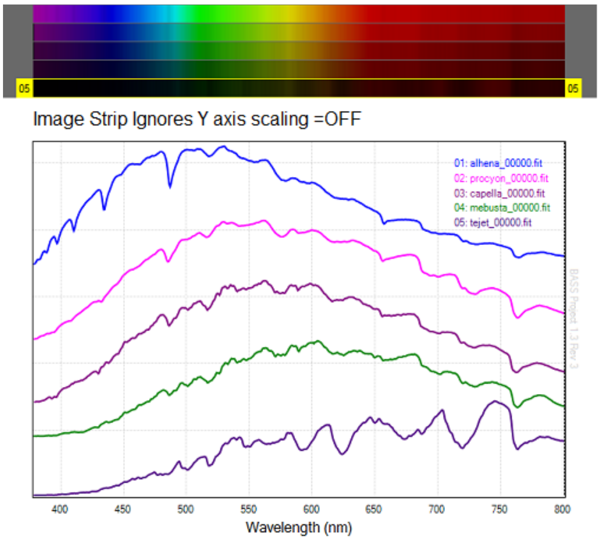


Image Strip Ignores Y axis scaling =OFF

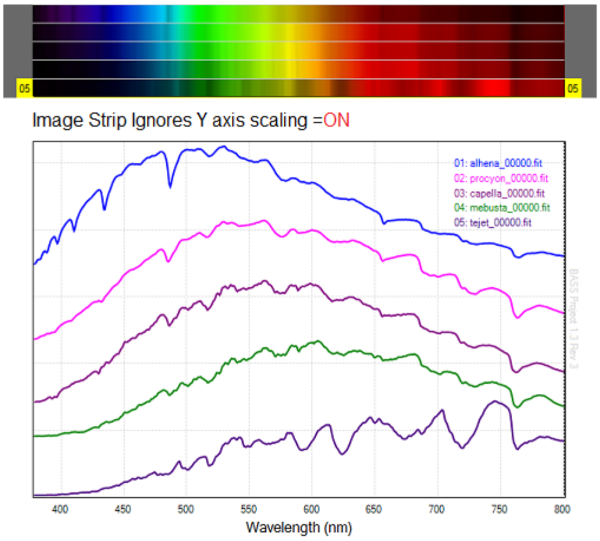
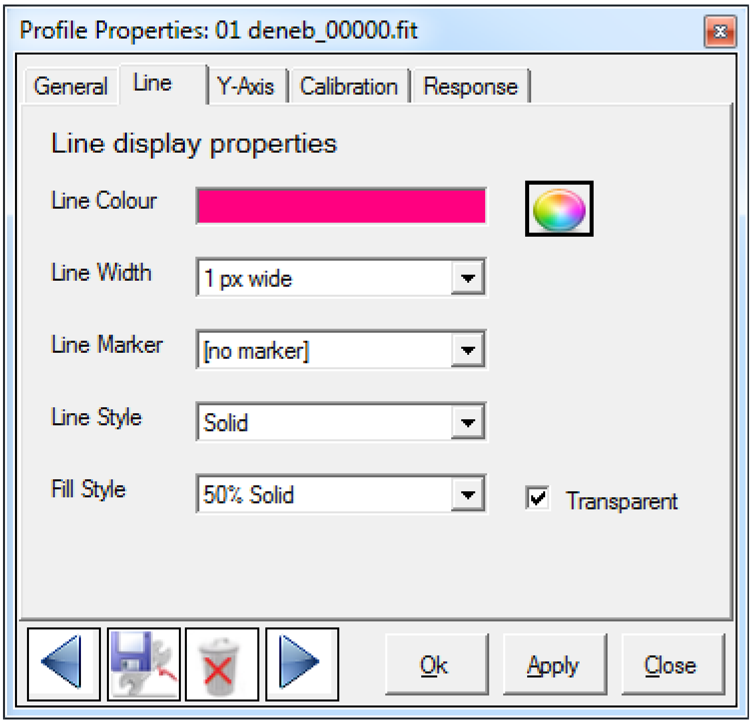


Image Strip Ignores Y axis scaling =ON

FITS button - for FITS images only, the button opens the FITS Header screen

BeSS button – for FITS images only, the button opens the BeSS (Be Star Spectra) settings screen

2.4.2 Line tab



Profile Properties: 01 deneb_00000.fit

Line display properties

Line Colour 🟥

Line Width: 1 px wide

Line Marker: [no marker]

Line Style: Solid

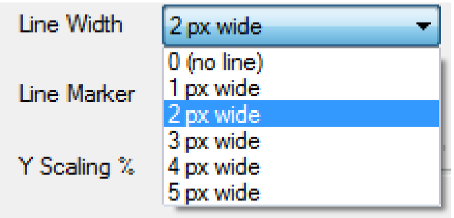
Fill Style: 50% Solid

☑ Transparent

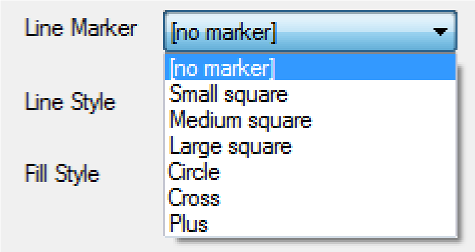
The Line setting values are saved at a project level.

Line Colour – By default, each image added to the project is automatically allocated a colour. The icon allows a profile to use a specific colour.

Line Width – The drop down list allows the width of the profile to be set.



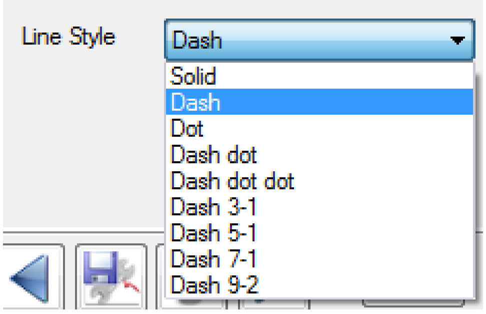
Line Marker – The drop down list provides options below to display a marker.



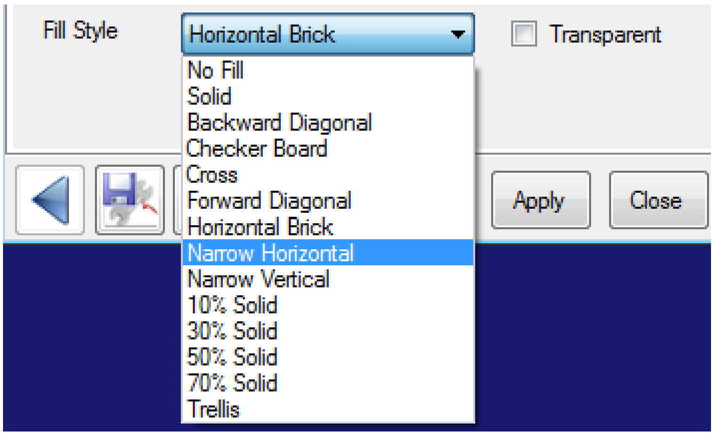
Note: Markers are most useful to show pixels when zooming in on a small region of interest; otherwise they will just make the line appear thicker.

Note: The profile will be hidden from the chart when [no line marker] is used with Line Width =0 and Fill Style = No Fill.

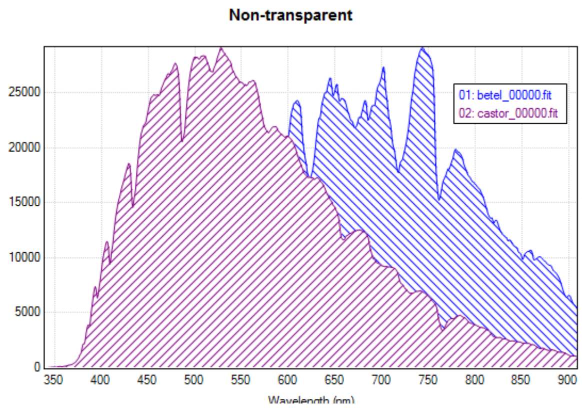
Line Style – The drop down list provides line style options. This can make it easier to differentiate between the profiles when printed in black and white.

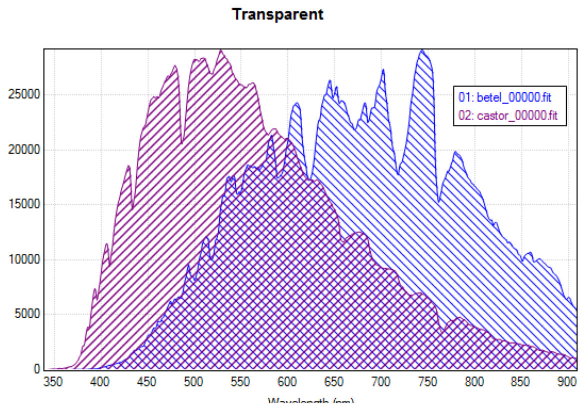


Fill Style – The drop down list provides various fill style options.

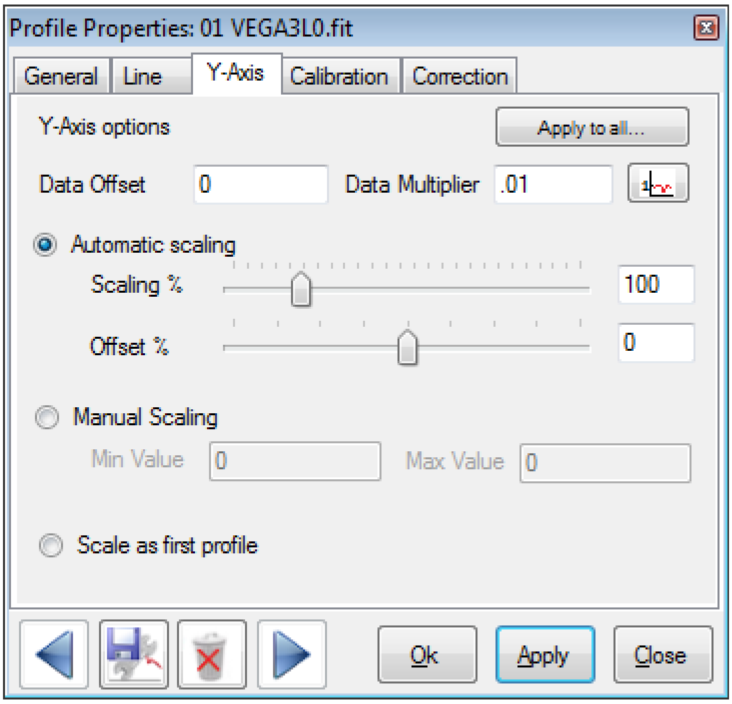


Transparent – The checkbox will make the Fill Style transparent. Does not apply to “No Fill” or “Solid”





2.4.3 Y-Axis tab



Profile Properties: 01 VEGA3L0.fit

Data Offset: 0

Data Multiplier: .01

● Automatic scaling

Scaling %: 100

Offset %: 0

○ Manual Scaling

Min Value: 0

Max Value: 0

○ Scale as first profile

The 'Data Multiplier' and 'Data Offset' textboxes allow raw data flux (ADU) values to be rescaled. The default values are 0 and 1 respectively.

The 'Apply to all' button will copy the Y axis settings to all other loaded profiles

The Normalise Flux button (to the right of the Data Multiplier) opens the Normalise Flux screen

This tab provides three main options for scaling the Y-Axis.

- Automatic scaling
- Manual scaling
- Scale as first profile

2.4.3.1 Automatic scaling

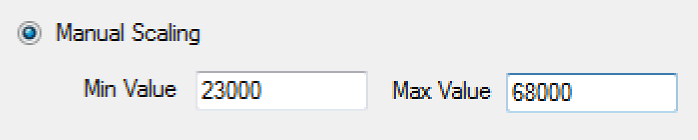
This is the default option and will automatically scale the profile to fit the range of intensity values (within the X-axis region) to the height of the chart.

Y Scaling % - The slider and textbox allow the magnitude of the profile displayed to be increased or decreased (i.e. enlarge or reduce the profile). Press Enter after editing the textbox to apply.

Y Offset % - The slider and textbox allow the vertical position of the profile to be increased or decreased (i.e. move the profile up or down). Press Enter after editing the textbox to apply.

The Y Scaling and Y Offset (and associated textboxes) are only enabled when the Automatic scaling option is chosen

2.4.3.2 Manual scaling



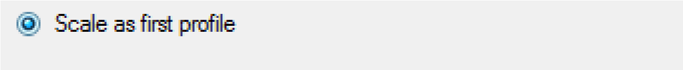
● Manual Scaling

Min Value 23000 Max Value 68000

Scaling will be set using the minimum and maximum (ADU) flux values into the textboxes provided. Ensure you enter valid flux values otherwise the profile may not be shown.

The textboxes are only enabled if the Manual Scaling option is chosen.

2.4.3.3 Scale as first profile

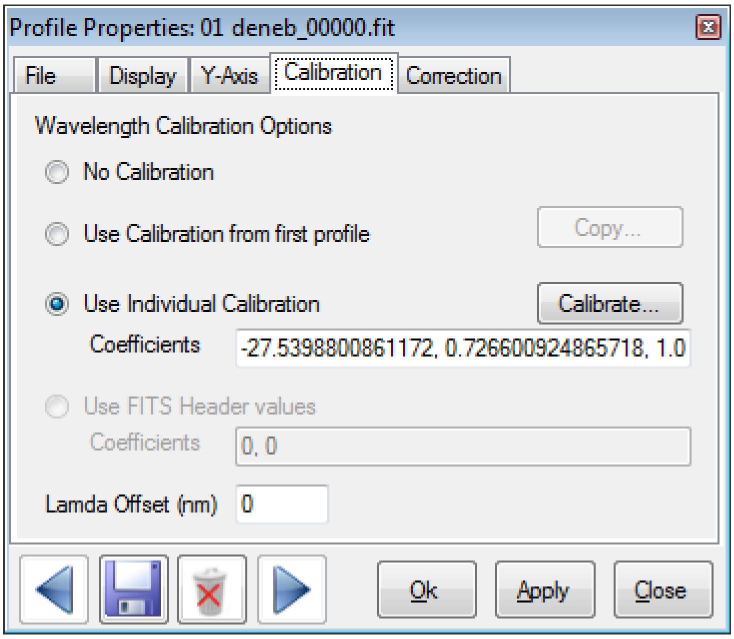


● Scale as first profile

The profile will use the same the minimum and maximum flux scaling values as the first profile. This is useful to compare spectra taken on several sessions with the same camera settings.

Note: The default chart Y-axis values are those of the first profile. Subsequent profiles added can have their own scaling which can be misleading.
Use 'Scale as first profile' to use a common scaling. Alternatively, enable a second y-axis on the RH side (see y-Axis tab in Chart Settings)..

2.4.4 Calibration tab


Profile Properties: 01 deneb_00000.fit

Wavelength Calibration Options

○ No Calibration

○ Use Calibration from first profile

● Use Individual Calibration

Coefficients: -27.5398800861172, 0.726600924865718, 1.0

○ Use FITS Header values

Coefficients: 0, 0

Lamda Offset (nm): 0

This screen provides various options for selecting which calibration option or coefficients to use. For details of creating a calibration and/or to see the calibration points, see the Wavelength Calibration section.

The choice of calibration option (the radio button selected) is saved at a project level (i.e. you need to save the project to preserve the setting).

No Calibration – Radio button allows calibration to be turned off. This will remain off when processing a DAT file profile that is already calibrated by having wavelength in the first column.

Use Calibration from First Profile – Radio button allows the profile to temporarily inherit the calibration of the first profile.

This is useful for when multiple profiles having the same calibration or dispersion are added to a chart. This is the default option when uncalibrated profiles are opened when the first profile is calibrated.

> *Profiles having the same dispersion (but differing offsets) can be manually aligned by setting the Image Strip View to 'Raw Image' or 'Synth Binned (raw)' and moving the image strips horizontally using the mouse while holding the Shift key.*
>
> *Aligning or sliding the images will have no effect on the chart unless the Use Calibration from First Profile option is selected.*

The "Copy" button has been provided to copy the calibration dispersion from the first profile and incorporate any offset from manual alignment of the image strips. Press Save to store the calibration. Once the calibration has been copied, the first profile can be removed.

Use Individual Calibration – Radio button to use calibration derived using this application.

The Coefficients textbox allows advanced users to read & access the polynomial calibration terms. Clearing the text box will remove calibration. The coefficients are saved in the BASS image information(.info.bas) file.

The “Calibrate” button will launch calibration mode. This will start a new calibration or edit an existing calibration.

Note that the coefficients are stored within the .info.bas file in nanometer units with a unit conversion applied where necessary

Use FITS Header values – For FITS images only. Radio button to use the calibration values held in the FITS Header (in CRVAL1 & CDELT1 keyword values). This currently supports linear FITS calibration tags only.

The read only textbox shows the values from the FITS header.

The BeSS settings screen can be used to populate the FITS header calibration values.

Lamda Offset – Textbox allows a manual shift of calibration by the specified negative or positive offset in nm. *This offset remains in nanometers regardless of the selected wavelength unit.*

Note: Changing calibration settings can have adverse effects if the profile has instrument response settings (because response curves depend on wavelength).

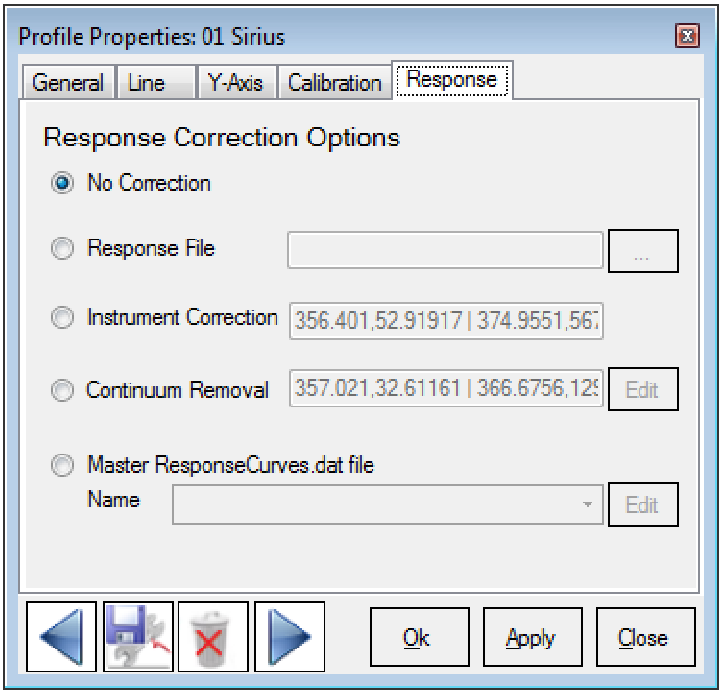
2.4.5 Response tab

The Response tab provides a choice of options for managing instrument and continuum response corrections.

The choice of correction option (the radio button selected) is saved at a project level since this can be project specific. You need to save the project to store this setting.

The response values in the text boxes are saved in the BASS image information file (.info.bas) file.

Note: Response correction settings are only valid for the calibration setting used when they were created. Corrections can give erratic results if the calibration is removed or altered.



Response Correction Options

● No Correction

○ Response File

○ Instrument Correction 356.401,52.91917 | 374.9551,56

○ Continuum Removal 357.021,32.61161 | 366.6756,12

○ Master ResponseCurves.dat file

Name

No Correction – Radio button allows existing correction to be turned off. This can remain off when processing a profile that has already had correction applied at the source.

This is the default setting when a profile is added to a project. Remember to select one of the options below if correction needs to be applied, or save as a project to automatically apply correction when next loaded.

Response File – Radio button allows the correction to be loaded from a response profile DAT file (created by BASS or other software). The adjacent browse offers a Windows file dialog to help locate the file.

If you want to use an instrument response file in FITS format, select ‘No Instrument Correction’ and divide your profile with your response file to obtain a new corrected profile.

Instrument Correction – Radio button allows the profile to use the instrument response correction points created in the Continuum & Response Shaper screen.

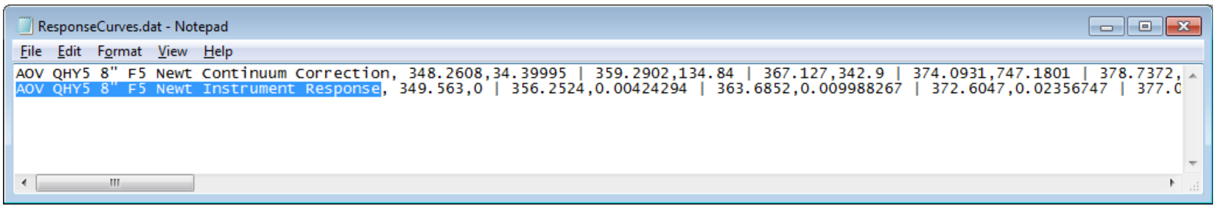
The Points text box provides access to the data points that make up the response correction

Continuum Removal - Radio button allows the profile to use the continuum removal correction created in the Continuum & Response Shaper screen.

The Points text box provides access to the data points that make up the response correction. The adjacent Edit button allows the correction to be modified.

Master ResponseCurves,dat file – Radio button allows the profile to select a response correction from the drop down list.

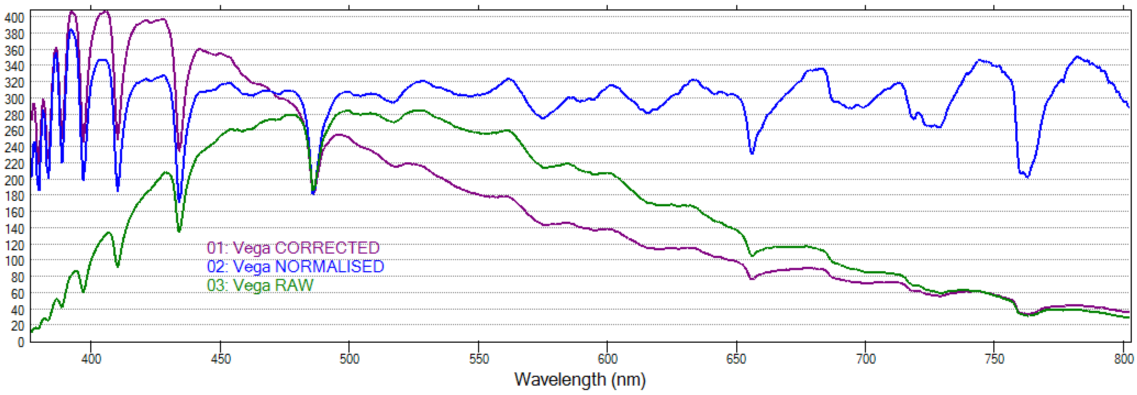
Named profiles are generated by the Continuum & Response Shaper screen and are stored in the .\Instruments\ResponseCurves.dat text file which can be edited via the Edit button next to the drop down list.



```
AOV QHY5 8" F5 Newt Continuum Correction, 348.2608,34.39995 | 359.2902,134.84 | 367.127,342.9 | 374.0931,747.1801 | 378.7372,
AOV QHY5 8" F5 Newt Instrument Response, 349.563,0 | 356.2524,0.00424294 | 363.6852,0.009988267 | 372.6047,0.02356747 | 377.
```

The text file is in comma separated format. The first column is the name of the correction, the remainder being the data points. Editing should be limited to renaming the first column and/or removing unwanted rows (to minimise the risk of corrupting the data points).

Note: To simultaneously display the uncorrected, corrected and normalised versions of a single profile, load the same profile three times and set each to a different response correction option.



2.5 Image Strips

The area between the tool bar and the chart will display the image strips loaded, including reference spectra (but not Planck curves).

Double clicking on an image strip will load the Profile Properties

Right mouse clicking on an image strip will provide a pop-up menu allowing access to many other functions.

Image strip pictures can be copied to the clipboard or to an image file using the options under the main Chart menu.

2.5.1 Image Strip View type selection

The image strips work in conjunction with the Image Strip View drop down list available on the toolbar.

There are nine Image Strip View options:

Raw Image

Shows the raw images in actual 100% size or zoomed at 25%, 50%, 200% or 400%.

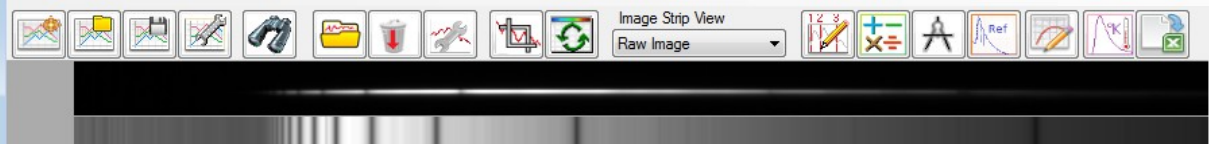


Image Strip View
Raw Image

Note: Reference spectra and generated one dimensional profiles are shown extended to the default image strip height setting (in the Chart Settings screen).

Selecting one of the five Raw Image options also enables the main Image menu and sub menus. See the Image processing menu section for details.

Holding the Shift key allows an image to be moved or aligned.

Holding the Control key updates the LH status bar to show pixel X & Y position and ADU value.

Synth Binned (raw)

Shows grey binned (average of vertical binned pixels) image in actual image width.

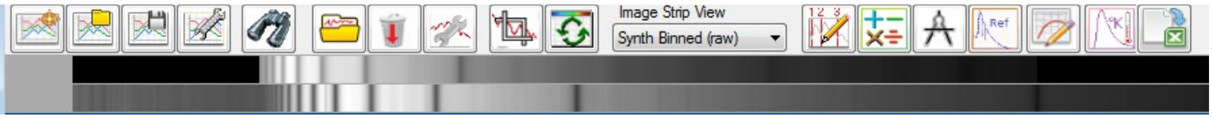


Image Strip View
Synth Binned (raw)

Synth Colour (raw)

Shows false colour binned (average of vertical binned pixels) image in actual image width.

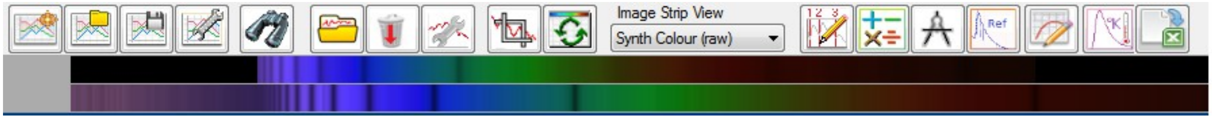


Image Strip View
Synth Colour (raw)

Note – the displayed colours will be meaningless if the chart is not calibrated

Synth Binned (stretch)

Shows grey binned (average of vertical binned pixels) image stretched to the width of the chart.

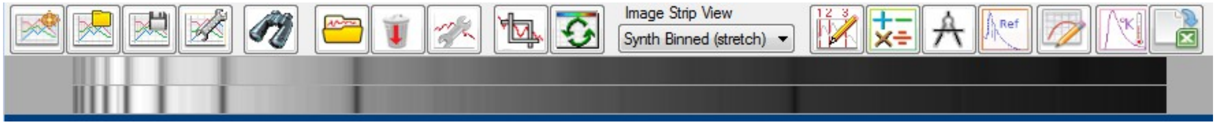


Image Strip View
Synth Binned (stretch)

Synth Colour (stretch)

Shows false binned (average of vertical pixels) image stretched to the width of the chart.

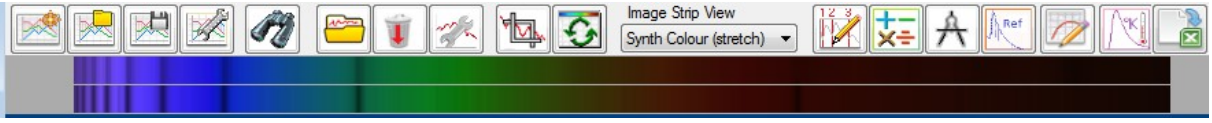
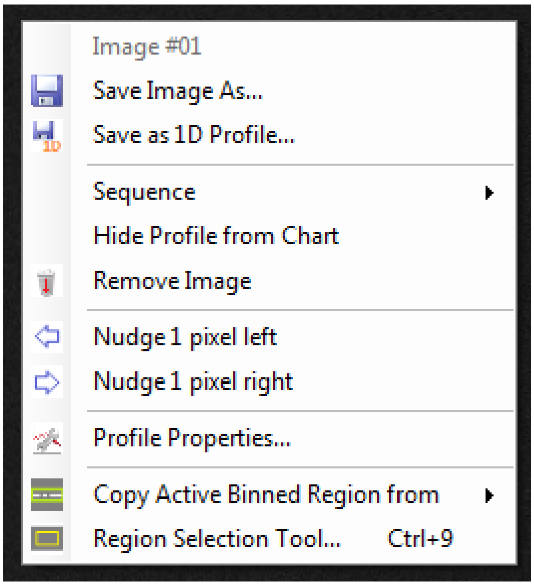


Image Strip View
Synth Colour (stretch)

Note – the displayed colours will be meaningless if the chart is not calibrated

The stretch options are the most useful for final presentation since the chart and image lines will be synchronised. The other options are useful for alignment and/or checking if things are as expected.

2.5.2 Context Sensitive Image Strip Menu



Right mouse clicking on an image strip will show a pop-up menu with options for the associated profile.

- Profile # - The first item is not a menu, but displays the profile sequence number of the selected profile
- Save Image As – Opens a Save File dialog to save the selected image
- Save as 1D Profile– See section Save As 1D
- Sequence – Change the sequence (order in image strip view) of the current image
- Hide Profile from Chart – toggle visibility of the profile in the chart. When ‘hidden’ the profile display properties are set to ‘Line Width=0’ and ‘No Marker’. When ‘unhidden’ then ‘Line Width=1’

- Remove Image – the icon prompts to remove the current selected image strip and associated profile

- Nudge left 1 pixel – Slides the selected image strip by a single pixel for alignment purposes (see next section). This is disabled for the stretch image strip options

- Nudge right 1 pixel – as per Nudge left but in the other direction

- Profile Properties – Open the Profile Properties screen for the selected profile.

- Copy Active Binned Region from – This is used to apply the same active binned region from a science image onto a calibration image. Details can be found in the BASS Project 1.9.5 Release Notes.

- Region Selection Tool – Shortcut to open the Region Selection Tool.

2.5.3 Manual Alignment of Image profiles

The image strips can be slid in the horizontal direction for manually alignment purposes when the shift button is held down. Image strips can also be slid using the Nudge left/right option by right clicking on an image strip.

Sliding image strips is applicable to the following scenarios:

- Alignment of a number of profiles prior to stacking
- Alignment of common features for profiles that have the same spectral dispersion
- Alignment of a profile with a calibration profile.

The manual alignment can be used in conjunction with the “Use Calibration From First Profile’ option (in Calibration tab of the Profile Properties screen) to calibrate one profile from another having the same dispersion but a different offset.

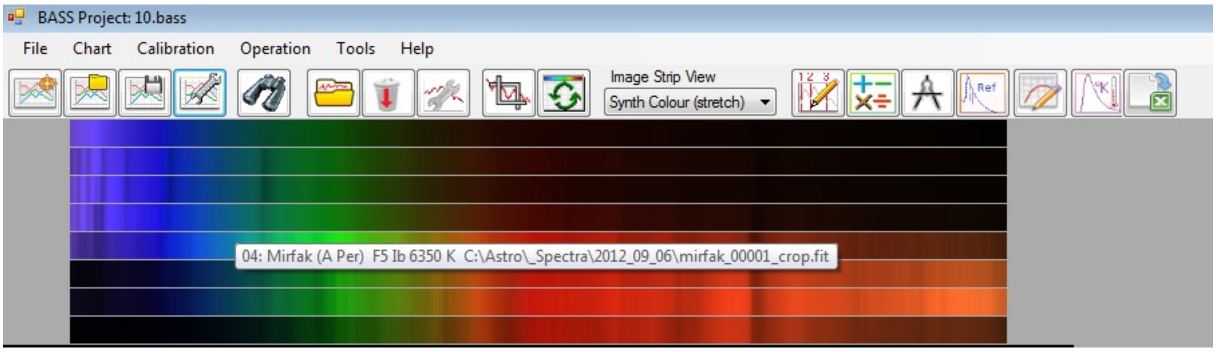
Manual alignment can be reset (removed) by clicking the Reset button in the Stack and Align Profiles screen.

Note: Manual alignment is not allowed when a stretch mode option on the Image View drop down list is selected. A warning is displayed on the LH status bar

Note: Alignment is limited to single pixels only. It is possible to improve the accuracy of alignment by using the 200% or 400% Image View options or first resampling images to a larger number of pixels.

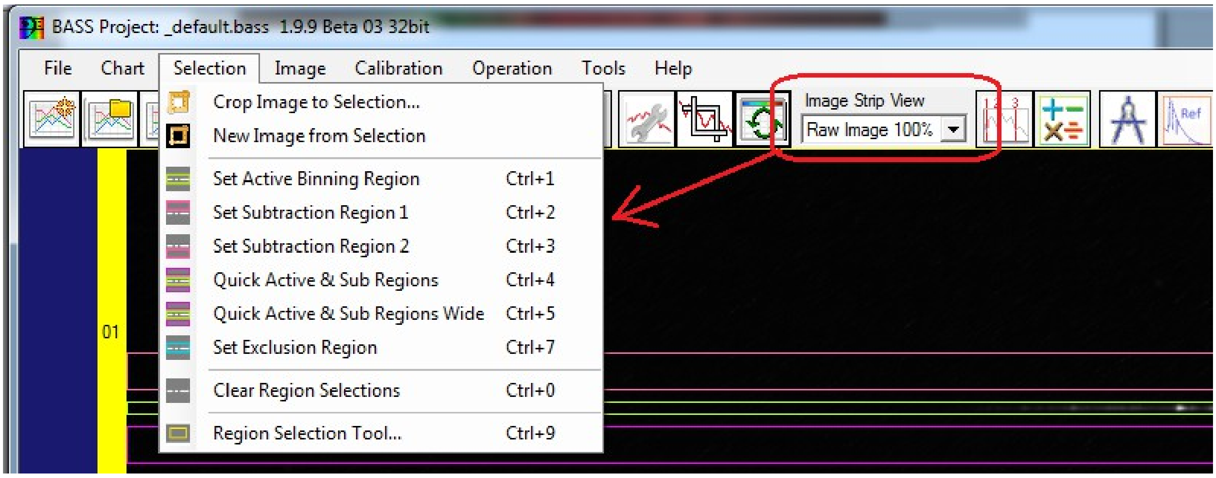
2.5.4 Identification of image strips

Hovering the mouse over an image strip will show the sequence number, caption and file path of the image underneath.



2.6 Selection menu

The Selection menu is only enabled when a two dimensional image is selected and the Image Strip View drop down list is set to a Raw Image option.



2.6.1 Selection regions

The following options act upon on the rectangular area selected using the mouse on the current image

- Crop to Selection – crops the image to the current selection. The cropped image can be saved using the 'Save Image As' menu

- New Image from Selection – adds the selected area as a new image to the project. The default filename is <oldFileName> + "_crop".

- Set active binned region – Binning will average only pixels within the height of the selected region. Shortcut access Ctrl + 1.

- Set subtraction region 1 – Defines the height of background region 1 to be subtracted from the active binned region. Shortcut access Ctrl + 2.

.

- Set subtraction region 2 – Defines the height of background region 2 to be subtracted from the active binned region. Shortcut access Ctrl + 3.

- Quick active & sub regions – Creates active region based on selection but also adds defaults for subtraction regions 1 & 2 which may require subsequent tuning. Shortcut access Ctrl + 4

- Quick active & sub regions wide – As previous option but with wider spacing of regions. Shortcut access Ctrl + 5

- Set Exclusion region - This defines a region, shown using light blue lines, where rows will be ignored from binning. This may be useful to exclude target spectrum contamination from a reference spectrum. Shortcut access Ctrl + 7.

- Clear selections – clears the active, excluded & binned selections/regions (and renders the profile using an average of pixels over total image height). Shortcut access Ctrl + 0.

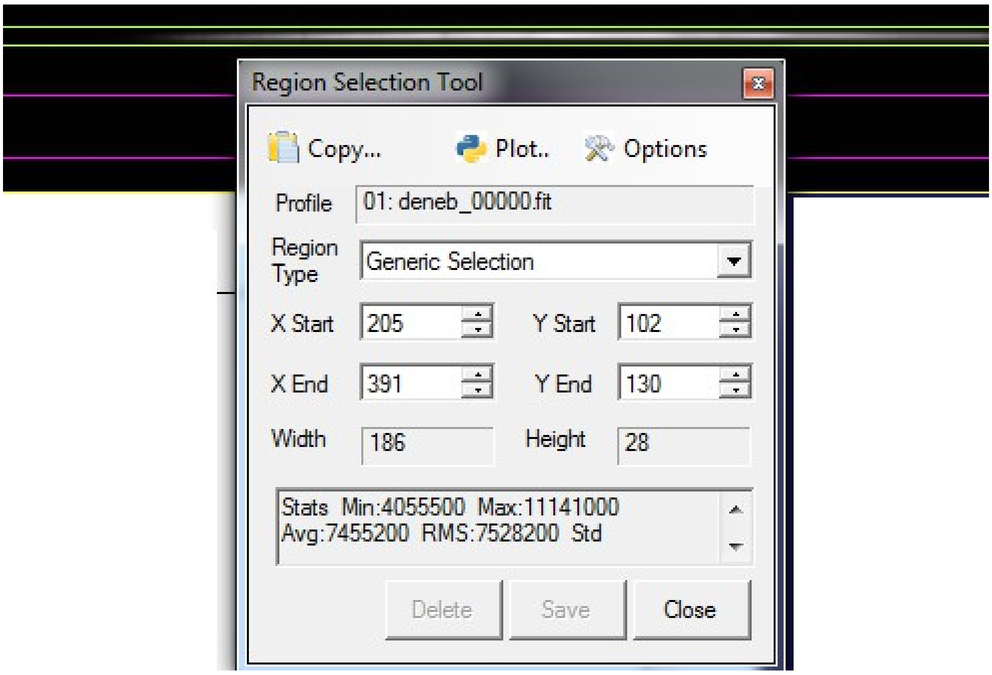
  Region Selection Tool - Opens the Region Selection Tool screen (see below) for fine adjustment of a selected area on an image. Shortcut access Ctrl + 9.

Any individual region no longer required can be removed using the Region Selection Tool.

Changes to regions will take effect when the chart is refreshed (press F5 or click Refresh button).

2.6.2 Region Selection Tool

This screen is accessed from the Selection menu or aright click on an image strip. It allows finer control of the binning and background regions than using a mouse. It also allows individual regions to be removed.



Profile 01: deneb_00000.fit

Region Type Generic Selection

X Start 205 Y Start 102

X End 391 Y End 130

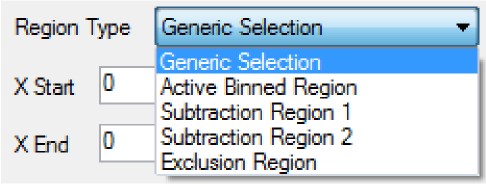
Width 186 Height 28

Stats Min:4055500 Max:11141000
Avg:7455200 RMS:7528200 Std

The screen provides the following features:

- Profile - This is a read only text box that displays the active profile that changes will be applied to.

  Region Type – A drop down list allowing the type of region

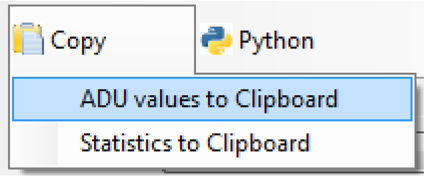


  Changing the Region Type will update the X and Y values. The Generic Selection is useful for accurately setting an area prior to image cropping

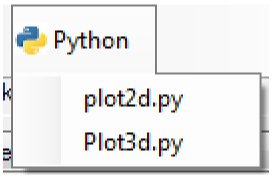
- X Start – First X pixel of area.
- X End – Last X pixel of area.
- Y Start – First Y pixel of area
- Y End – Last Y pixel of area
- Width – a read only field calculated by X End minus X Start
- Height – a read only field calculated by Y End minus Y Start

- Statistics Area - A read only selectable text box that displays the flux statistics of the current area defined by the X and Y values

- Copy – A drop down menu provides the following options
    - Copies the ADU values to the Windows clipboard in tab delimited format for subsequent analysis (e.g. paste into Excel)
    - Copies the Statistics to the Windows clipboard

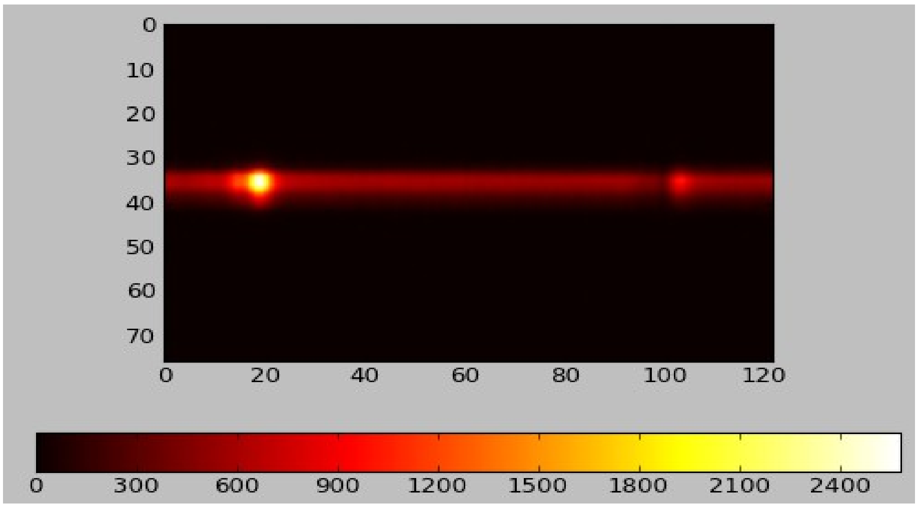


- Python – A drop down menu provides the following options to render the selected region using compiled Python scripts.

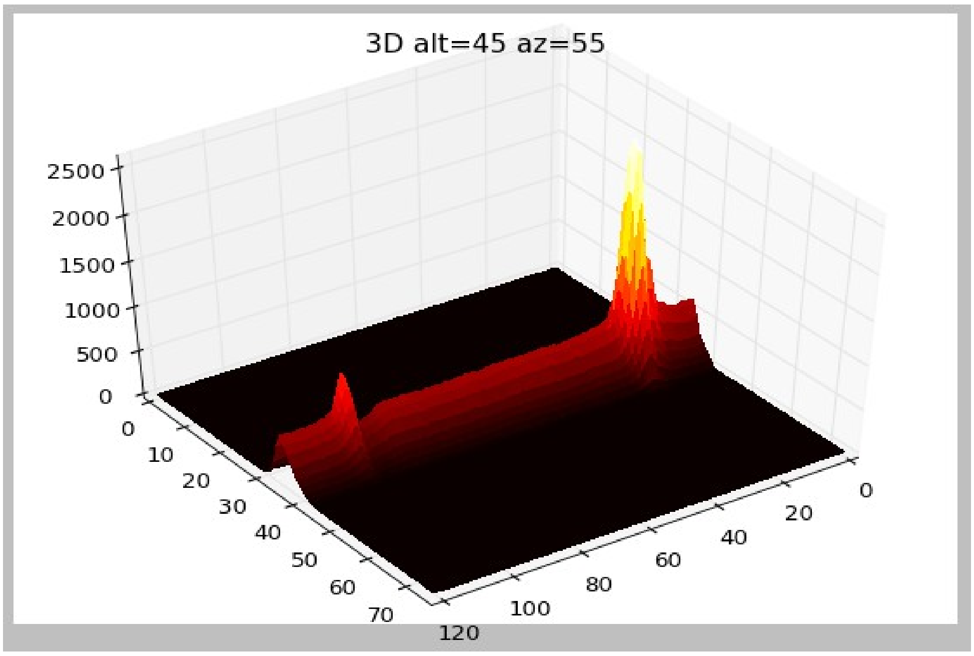


You must have the PythonFileFiles folder installed to run these plot options.

Plot2d.py - Runs the two dimensional Python colour map plot passing in the selected pixel area. Close the DOS prompt window to return to BASS.



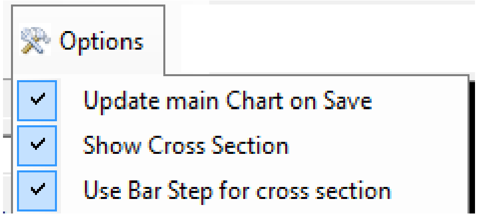
Plot3d.py - Runs the 3 dimensional Python colour plot passing in the selected pixel area.



On running, the user is prompted for the altitude and elevation viewpoint for the 3D perspective. You can edit the default values or just press Enter to accept.

Close the DOS prompt window to return to BASS

- Options – a drop down menu provides the following options



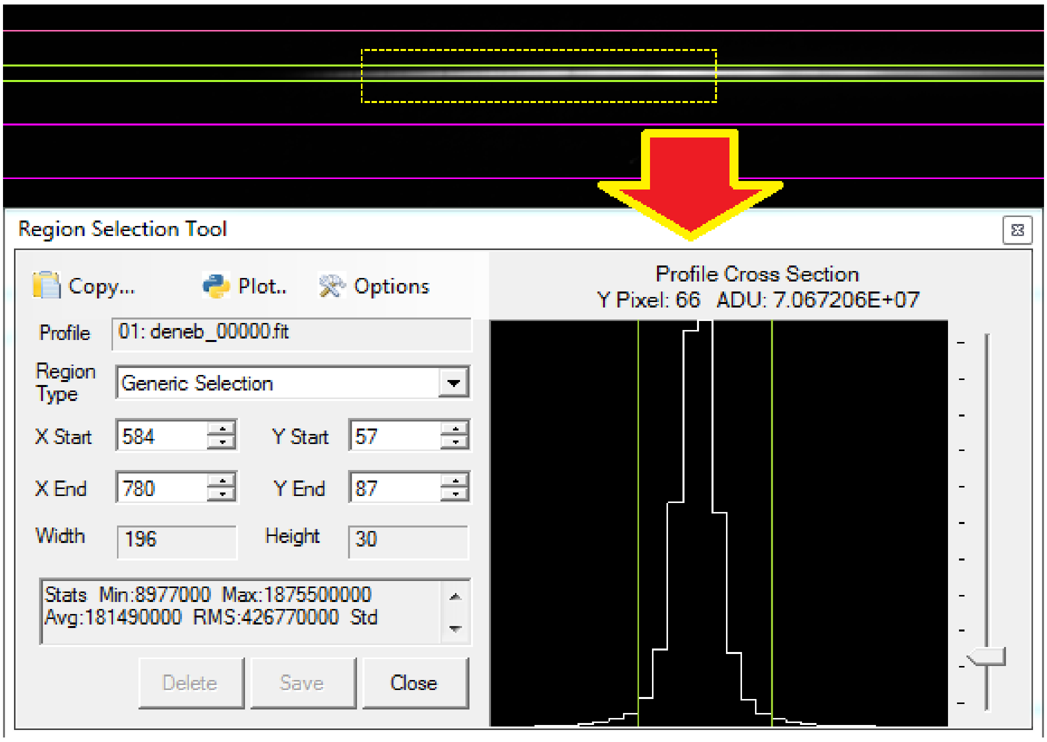
☑ Update main Chart on Save
☑ Show Cross Section
☑ Use Bar Step for cross section

- Update main Chart on Save – Updates the main chart to synchronise regions when the Save button is pressed
- Show Cross Section – Show/hide the RH Profile Cross Section panel
- Use Bar Step for Cross Section – Toggle cross section plot to use joined lines or bar steps.

Cross Section Panel – shows the cross section of profile based on current selected region. Moving the mouse over the panel will show ADU and pixel position. The screen can also be resized.

A vertical slider control on RH side also shows threshold in terms of maximum and minimum ADU.

The plot gets updated when a mouse selection is made on the Image Strip.



Y Pixel: 66 ADU: 7.067206E+07

Profile: 01: deneb_00000.fit

Region Type: Generic Selection

X Start: 584
Y Start: 57
X End: 780
Y End: 87
Width: 196
Height: 30

Stats Min:8977000 Max:1875500000
Avg:181490000 RMS:426770000 Std

- Remove – A button that removes values for the selected Region Type
- Save - The current area defined by X and Y values is saved for the selected Region Type
- Close – Closes the screen

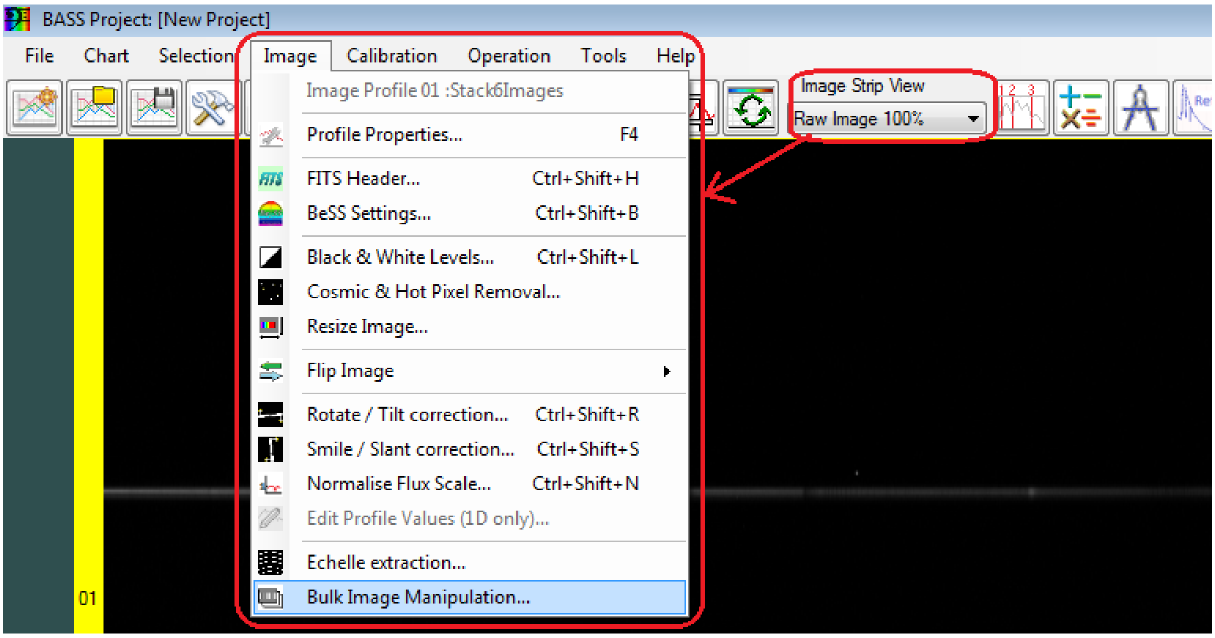
The best way to use this screen is to select a Region Type before adjusting the X and Y values. The X and Y values can set using the up/down arrow keys and/or making a selection on the active image.

The Active, Subtraction and Exclusion region types will span the full width. Therefore X Start and X End will be read only and set to 0 and full width respectively.

2.7 Image processing menu

The image processing functionality is for FITS image formats and is available under the main ‘Image’ menu. Sub menu items under the Image menu are enabled or disabled depending on the Image Strip View drop down list setting and whether the current Image is a two dimensional image, (or a one dimensional profile).

Note that keyboard shortcuts have been provided to make it easier to access the commonly used screens than using a touchpad or mouse alone. E.g. Ctrl+Alt+R will open the Rotate/Tilt Correction screen.



2.7.1 Image Profile number & caption

The first menu item is not an active menu; it just displays the sequence number and caption of the active image for information purposes

2.7.2 Profile Properties

This loads the Profile Properties screen for the active image.

2.7.3 FITS Raw Header

This opens the FITS Raw Header screen. (This is also available via the General tab of the Profile Properties screen).

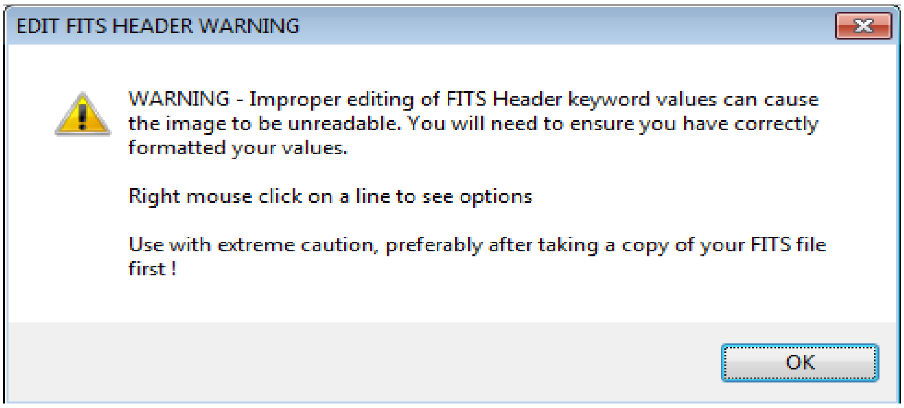
This screen allows the FITS header values to be examined or modified.

Forward and Back buttons allow navigation through loaded images.

A Find Text textbox allows searches to be made. Enter search text and press Find.

The Enable Edit checkbox allows changes to be made, but displays a warning message.

Warning - Don't make any changes to the FITS values unless you have a backup of your file and understand how FITS keywords should be formatted!

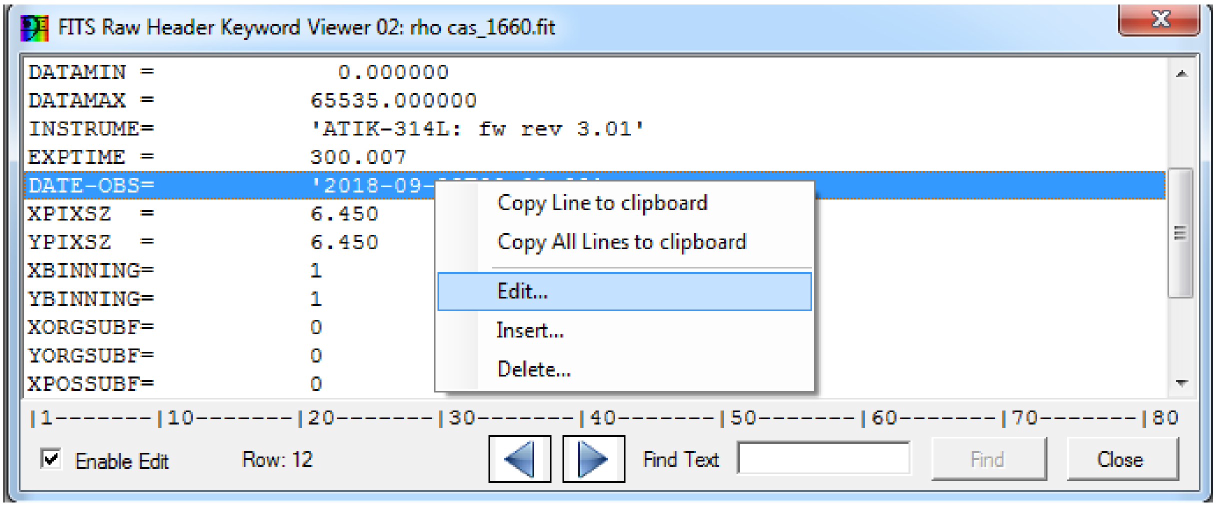


WARNING - Improper editing of FITS Header keyword values can cause the image to be unreadable. You will need to ensure you have correctly formatted your values.

Right mouse click on a line to see options

Use with extreme caution, preferably after taking a copy of your FITS file first !

A right mouse click menu allows access to copy, edit, delete & insert options.



```
DATAMIN =                 0.000000
DATAMAX =               65535.000000
INSTRUME=               'ATIK-314L: fw rev 3.01'
EXPTIME =               300.007
DATE-OBS=               '2018-09-
XPIXSZ  =               6.450
YPIXSZ  =               6.450
XBINNING=               1
YBINNING=               1
XORGSUBF=               0
YORGSUBF=               0
XPOSSUBF=               0
|1-------|10-------|20-------|30-------|40-------|50-------|60-------|70-------|80
```

Note the FITS file will need to be saved to make changes permanent

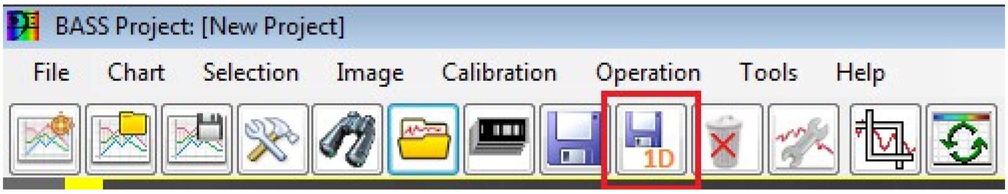
2.7.4 BeSS Settings

This opens the BeSS Settings screen

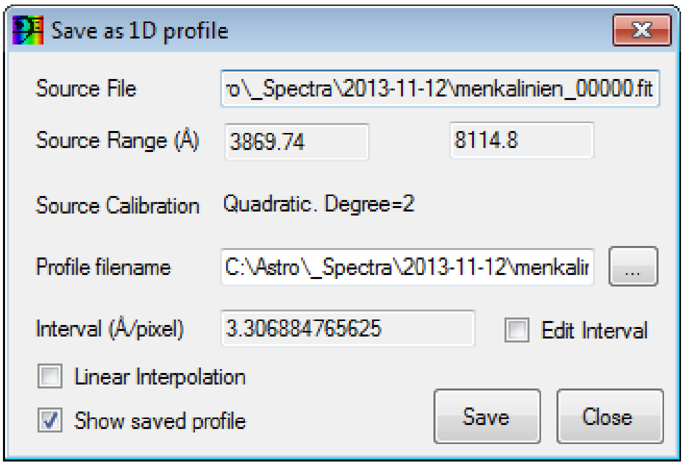
2.7.5 Save Image As

Prompts for file name to save the active image

2.7.6 Save As 1D



The Save As 1D screen can be accessed from the toolbar, File menu and by right mouse clicking on an image strip.



Source File: o_Spectra\2013-11-12\menkalinien_00000.fit

Source Range (Å): 3869.74 8114.8

Source Calibration: Quadratic. Degree=2

Profile filename: C:\Astro_Spectra\2013-11-12\menkalir

Interval (Å/pixel): 3.306884765625 ☐ Edit Interval

☐ Linear Interpolation

☑ Show saved profile

The purpose of this screen is to create a one-dimensional profile from a two dimensional image.

The detailed functionality is listed below:

- FITS Header values are copied from source to target image where applicable.
- The filename to save the new 1D profile is pre-populated with a default "_1D" suffix.
- Automatically populates the FITS header with a linear calibration if the source was calibrated.
- Restricts the profile start and end pixels/wavelength range as specified in the x-axis crop screen
- If the source image used a polynomial calibration, the profile is re-sampled using a default sampling interval based on the highest dispersion value within the specified wavelength range. A manual override checkbox to specify your own interval is also provided.
- An option is provided to select linear interpolation (rather than cubic spline) when a polynomial calibration was used.
- Calibration keyword values within FITS header will be saved in Angstrom unit by default.

- The screen has an option to display the new 1D profile in the project, (saving the effort of having to browse and open it).

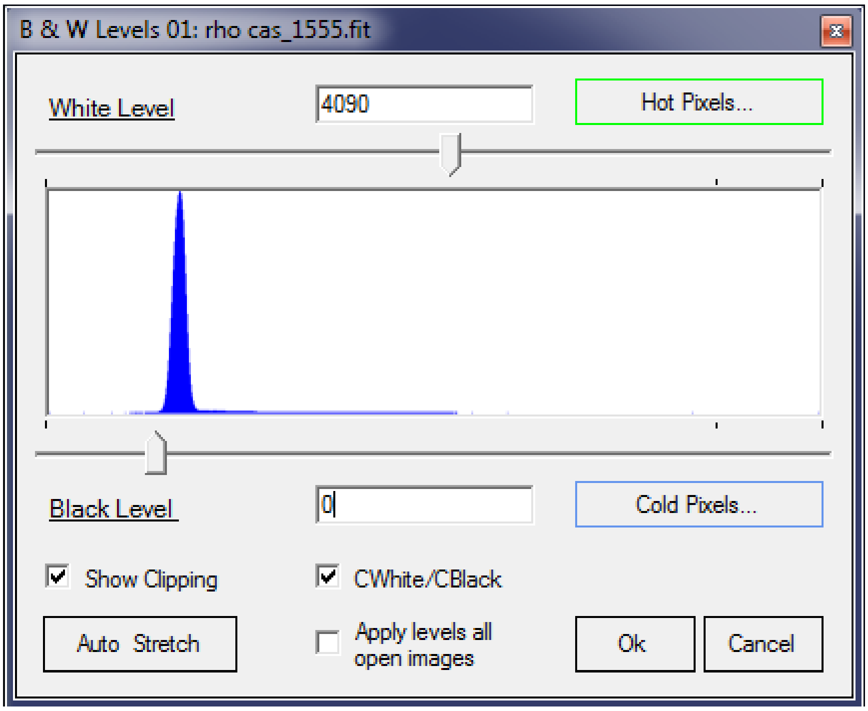
Once created, a one dimensional profile can be saved using the normal 'Save As'.

2.7.7 Black and white levels

This screen enables the FITS black and white levels to be adjusted and allows ADU level to be used for hot and cold pixel removal.

Changing levels will alter the appearance of the raw image, but won't affect the profile chart since this is automatically scaled.

The levels are stored to the CBlack & CWhite FITS header values when the image is saved, to be re-instated when the image is next loaded.


B & W Levels 01: rho cas_1555.fit

White Level: 4090

Black Level: 0

☑ Show Clipping

☑ CWhite/CBlack

☐ Apply levels all open images

The black and white levels can be set using the textboxes (press Enter after keying in a value) and/or using the sliders provided.

CWhite/CBlack - checkbox will set levels using CBlack & CWhite FITS header values where they exist.

Auto Stretch – button sets the levels based on the min and max detected values.

Show Clipping - checkbox is used to show pixels have have been clipped beyond a limit. Hot clipped are green. Cold clipped are blue. It also activates the Hot Pixels and Cold Pixels buttons.

Apply to All Open Images - checkbox will apply the black and white levels to all open images.

Simple Cold pixel removal method - Set the Black ADU level to show blue pixels to be removed. (You may need to temporarily adjust the white level to improve contrast or enlarge the image view). Click Cold Pixels button and confirm to apply changes. The histogram will be updated.

Simple Hot pixel removal method – Set White ADU level to show green pixels to be removed. Click Hot Pixels button to confirm and apply changes and update the histogram.

Note: Hot and cold pixel removal in this screen uses single threshold should be used with caution. There is also a dedicated Cosmic, Hot and Cold pixel removal screen that provides more sophisticated techniques.

2.7.8 Cosmic, Hot & Cold Pixel removal

The Cosmic, Hot & Cold Pixel removal screen allows bad camera pixels and random cosmic ray hits to be removed. The menu option is enabled for 2D images only. Hot pixels are usually dealt with by dark subtraction techniques (see Stack Images section). This screen allows hot pixel removal when no dark images are available.

Cosmic, hot & cold pixel removal should be prior to any processing that alters the position of pixels, (e.g. cropping, rotation, slant or tilt correction).

The hot pixel removal technique relies on the fact that the hot pixels on a spectral image will be in the same location as taken on a “dark” image. The information can then be saved to a 'cosmetic' file that can be reused on a number of images taken with the same camera (and temperature and exposure settings). It is also possible to remove hot pixels directly without a cosmetic file.

Bad pixels caused by cosmic rays are random (since they are caused by radiation striking the CCD sensor). Analysis and detection can therefore be carried out on the light image itself.

The actual process of removing a bad pixel is to replace its value with the median or average value of its neighbours.

The screen has two tabs. The Image tab is used to detect bad pixels and apply correction. The Cosmetic File tab is used to save and load cosmetic file containing a list of bad pixel positions.

2.7.8.1 Image tab functionality

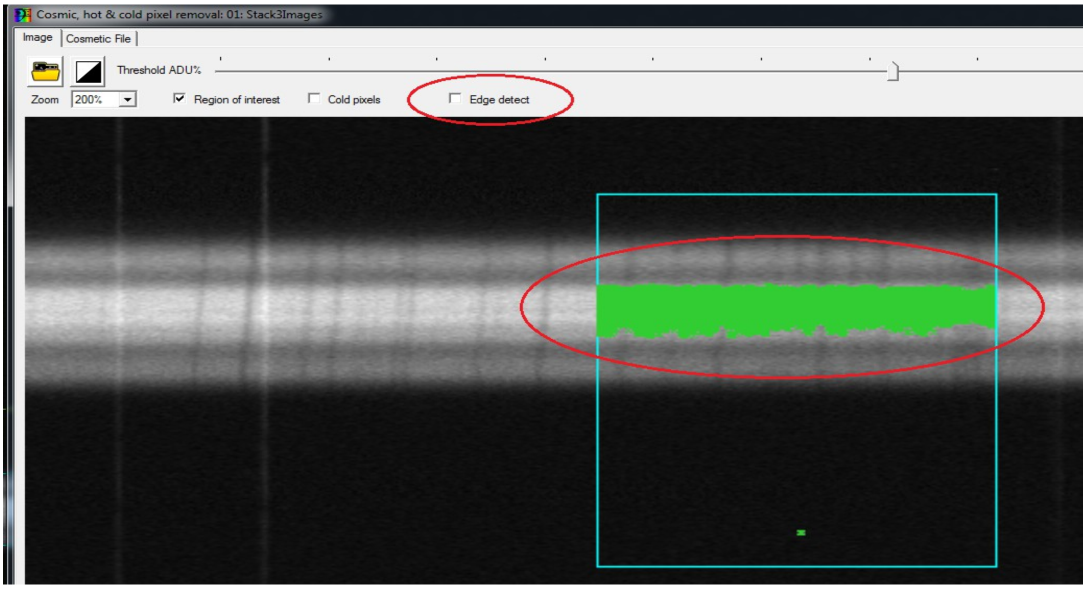
Open File icon – Button to open a different image to use for the detection of pixels. (e.g. load a dark file and use it to remove pixels from the current light image)

B & W Level icon – Button to adjust levels to make bad pixels easier to see.

Threshold ADU% - slider to set detection threshold as percentage (0 to 100%). The tooltip displays the ADU counts when mouse is hovered over.

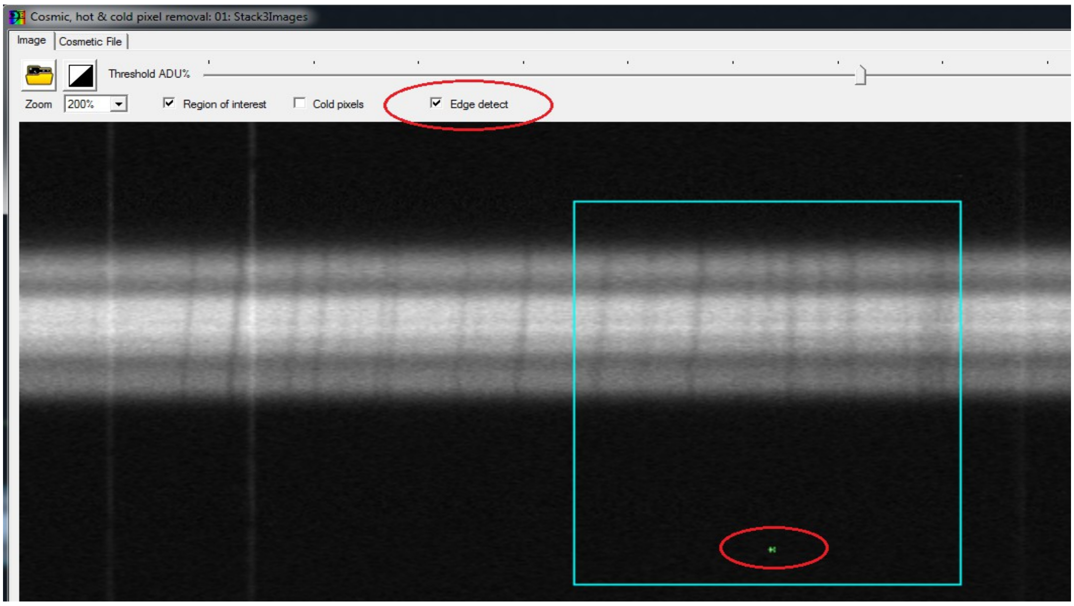
The direction for detection differs according to the Cold Pixel checkbox status.
Cold pixel = Off –> Start high, move to lower threshold to see hot pixels
Cold pixel = On -> Start low, move to higher threshold to see cold pixels

Depending on the image, values below 1.0% or above 99.0 % may be required, in which case it may be easier to key fractional values into the adjacent textbox (and press the Enter key).


Cosmic, hot & cold pixel removal: 01: Stack3Images

Zoom 200% ☑ Region of interest ☐ Cold pixels ☐ Edge detect

Excessive hot pixel detection without Edge detection


Cosmic, hot & cold pixel removal: 01: Stack3Images

Zoom 200% ☑ Region of interest ☐ Cold pixels ☑ Edge detect

Edge detection ignores main spectrum

Zoom – Drop down list offering 100%, 200%, 300% or 400% view. Zooming in helps to select a region for bad pixels within the spectrum and makes detected bad pixels easier to see..

Region of interest – Checkbox allows the detection of hot pixels to be restricted to one or more regions selected using the mouse. This is recommended as its more flexible than use a single threshold for the entire image).

Cold pixels – Checkbox to detect cold pixels when ticked. Turn off for hot pixels

Edge detect – Checkbox to compare pixel with neighbours (Turn off to detect based on ADU threshold).

Status bar – the status bar on the bottom of the screen shows the statistics of the selected range. This can help identify excessively high or low ADU that are indicative of bad pixels.

Median Correction – Checkbox to use median values when correcting values. Turn off to use average.

Apply to all open images – Checkbox will apply pixel correction to all open images.

Revert – Button to rollback pixel correction

Apply – Button that will apply pixel correction changes for the current selected region. When the Cosmetic File tab is pressed,the corrections will use the items in the Bad Pixel list.

Add+ - Pressing the Add button will add the bad pixels detected in the current region into the bad pixel list on the right of the screen.

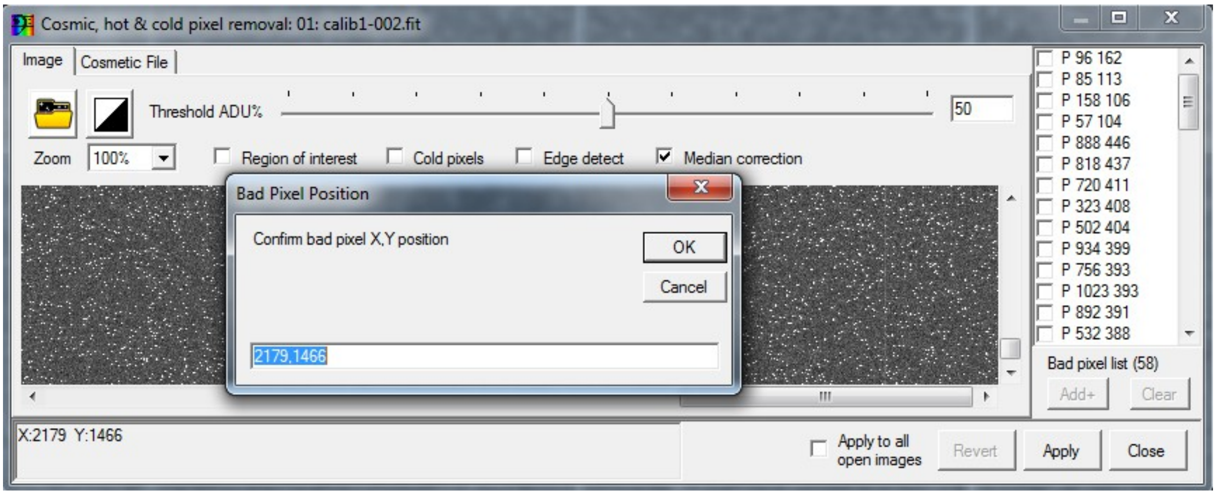
Clear – Pressing the Clear button will remove all items from the Bad pixel list. Individual items ticked will be removed if the Delete key is pressed,

Bad Pixel list – Listbox that is populated when Add is pressed to store detected bad pixels. The list can also be populated when a cosmetic file is loaded.

Detecting bad pixels in subsequent regions is used to build up the bad pixel list. This technique helps prevent false detection of ‘good’ pixels if a single threshold was applied to the whole image. The contents of the RH list can be saved as a cosmetic file using the Save button in the Cosmetic File tab.

Manually Add Bad pixels

In addition to bad pixel detection methods, bad pixels can also be added to the bad pixel list by double clicking on the image. A popup panel will then confirm the X Y coordinates and allow them to be edited. Note the X and Y values are separated by a comma.


Cosmic, hot & cold pixel removal: 01: calib1-002.fit

Threshold ADU% 50

Zoom 100%

☐ Region of interest ☐ Cold pixels ☐ Edge detect ☑ Median correction

Bad Pixel Position

Confirm bad pixel X,Y position

2179,1466

☐ P 96 162
☐ P 85 113
☐ P 158 106
☐ P 57 104
☐ P 888 446
☐ P 818 437
☐ P 720 411
☐ P 323 408
☐ P 502 404
☐ P 934 399
☐ P 756 393
☐ P 1023 393
☐ P 892 391
☐ P 532 388

Bad pixel list (58)

X:2179 Y:1466

☐ Apply to all open images

2.7.8.2 Cosmetic file tab functionality

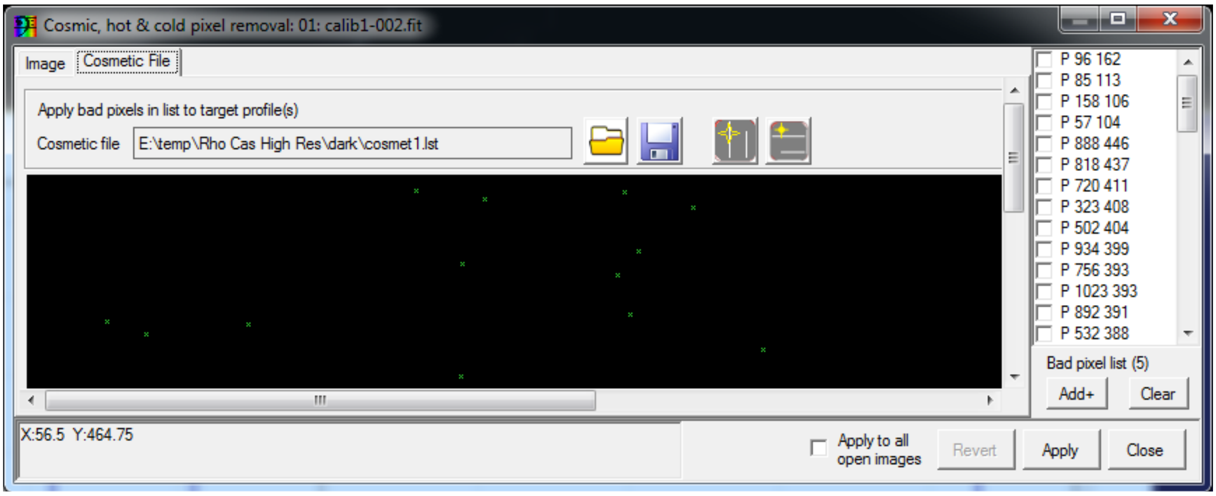
The Cosmetic File tab is used to save a list of bad pixels in a text file. The format of the file is broadly compatible with Christian Buil's ISIS software so a *.lst file, (as well as *.txt) extension is allowed

The cosmetic file contains four columns

- 'P' indicates a bad pixel (L= bad row or C = bad column)
- X coordinate of pixel
- Y coordinate of pixel
- ADU value of pixel

An example extract is shown below

```
P 371 708 950.423
P 372 708 1100.77
P 671 182 751.2372
P 672 182 877.7254
P 819 519 488.6667
P 1034 506 569.4341
P 1223 552 705.2795
P 1224 552 778.9944
P 1225 552 712.9644
```



Apply bad pixels in list to target profile(s)

Cosmetic file: E:\temp\Rho Cas High Res\dark\cosmet1.lst

☐ P 96 162
☐ P 85 113
☐ P 158 106
☐ P 57 104
☐ P 888 446
☐ P 818 437
☐ P 720 411
☐ P 323 408
☐ P 502 404
☐ P 934 399
☐ P 756 393
☐ P 1023 393
☐ P 892 391
☐ P 532 388

X:56.5 Y:464.75

☐ Apply to all open images

Open Icon – button opens a file dialog to select and load a *.lst or *.txt cosmetic file. This will update the screen area with the positions of bad pixels in green. It will also populate the bad pixel list on the right hand side of the screen.

Save Icon – button to save the items shown in the bad pixel list as cosmetic file.

Add Bad Column – button that will prompt for the column index of a bad column

Add Bad Row – button that will prompt for the row index of a bad row

Apply – button to apply correction using the items in the bad pixel list when Cosmetic File tab is selected. (This same button applies detected bad pixels based on selection when the Image tab is selected.

2.7.8.3 Bad pixel removal process

The basic bad pixel removal process is as follows:

- Ensure the Image Strip View is set to “Raw Image”
- Load image spectra into a new BASS Project session.
- Click to select the image loaded that contains bad pixels. This is the profile that correction will be applied to.
- Click on the Image -> Cosmic, Hot & Cold Pixel removal menus to open the screen. This load a copy of the active image to be used to detect bad pixels.
- Optional. Click on the Open Dark File icon to load a different image, such as a dark image, to use for detecting bad pixels.
- Click the Region of Interest checkbox.
- Ensure the Cold Pixels checkbox off (not ticked)

- Adjust the threshold slider to detect hot pixels. Detected pixels are highlighted using a very small green X. Setting zoom above 100% helps see isolated bad pixels. Experiment using the Edge Detect checkbox.

- Fine tune the threshold to avoid false detection of pixels on the spectrum itself.

- To save a cosmetic file, click the Save icon in the Cosmetic file tab. Enter filename and select *.lst or *.txt file type.

- If you wish to apply the hot pixel removal to all the open images then tick on the “Apply to all open images” check box before clicking Apply.

- Click on the Apply button

To remove hot pixels using a saved cosmetic file

- Open the Cosmetic, Hot & Cold Pixel removal screen

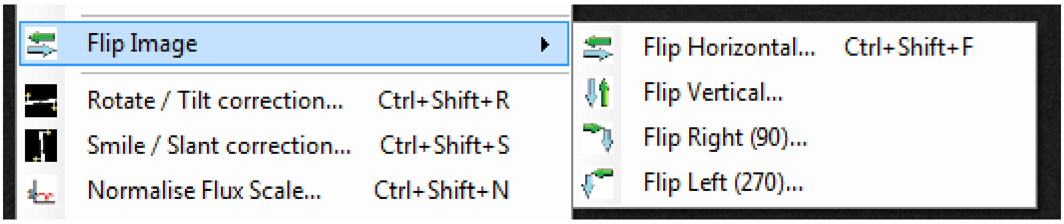
- Click the Cosmetic File tab

- Click on the Open icon in the Cosmetic File panel and select a file. This will populate the bad pixel list on the RH side.

- Click on the Apply button

2.7.9 Flip Image

A spectral profile should be displayed such that shorter (blue) wavelengths are on the left and longer (red) wavelengths are on the right. This function will flip the image as required. The child menu provides horizontal, vertical, right and left flip options.



To flip multiple images simultaneously, see the Bulk Image Manipulation screen section

2.7.10 Rotate/Tilt image

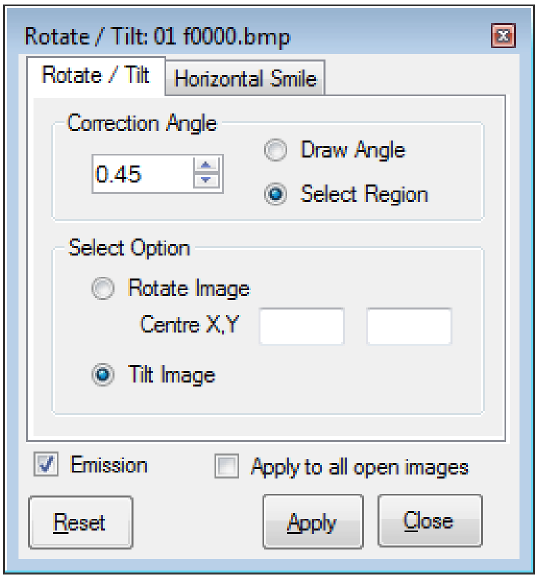
This allows an image to be rotated, tilted or have horizontal smile correction in order to correct for when the spectrum dispersion direction is not straight and horizontal relative to the camera sensor. Enabled for two dimensional images only.

Refer to Appendix C – Rotate/Tilt/Smile/Slant correction for how to identify the different types of corrections.

Note: Care should be taken to align the spectrum with the camera axis in the first place to minimise the degree of correction required. This allows the camera to capture the data with better resolution and prevents artefacts that can be caused by correction.

2.7.10.1 Rotate / Tilt tab

The Rotate function is accessed from the Image menu (for a selected FITs image when the Image Strip View has one of the Raw Image options selected).



Rotate / Tilt: 01 f0000.bmp

Correction Angle
0.45
○ Draw Angle
● Select Region

Select Option
○ Rotate Image
Centre X,Y
● Tilt Image

☑ Emission
☐ Apply to all open images

Correction Angle panel – Offers a number of different options to enter or derive the correction angle

> Angle box – A textbox to allow entry of a known correction angle (in degrees). Negative numbers are clockwise, positive numbers anticlockwise. Use the spin up/down arrows or arrow keys to alter the angle in 0.1 degree increments
>
> Draw Angle – use the mouse to draw a line along the spectrum corresponding to the observed rotation or tilt angle. The Correction Angle is calculated as the mouse is released. This is useful for angles greater than approximately 5 degrees, or where selecting a region would not be appropriate (e.g. on a busy slit-less image)
>
> Select Region – use the mouse to draw a rectangle that encompasses the spectra to be corrected. The angle is calculated as the mouse is released. Recommended, especially for angles less than 5 degrees

Selection Option panel – this panel offers the choice to rotate the image or apply tilt correction.

> Rotate Image – select this option to rotate the image by the correction angle. Recommended for slit-less spectra.

Centre of Rotation – leave the X and Y textboxes blank to rotate about the centre or specify the rotation point. This applies to rotation only. It has no effect on tilt.

Tilt Image – select this option to apply tilt correction by the correction angle. Recommended for slit spectra.

Emission – this checkbox is ticked by default ready for emission type spectra or using a bright line. Turn if off for absorption spectra (or where you are correcting a dark feature for an extended target such as the Moon).

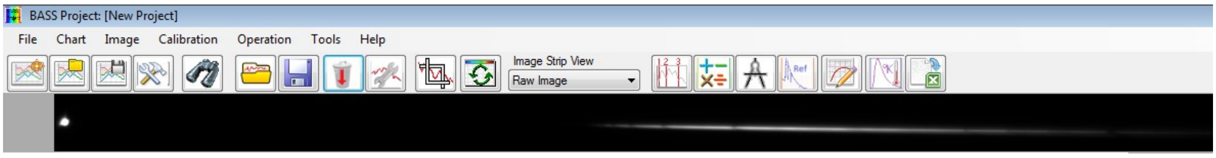
Apply to all open images – when this checkbox is ticked, the Apply button will apply the correction to all open images.

Apply – this button performs the rotation of the selected image (or all open images) using the angle and centre specified.

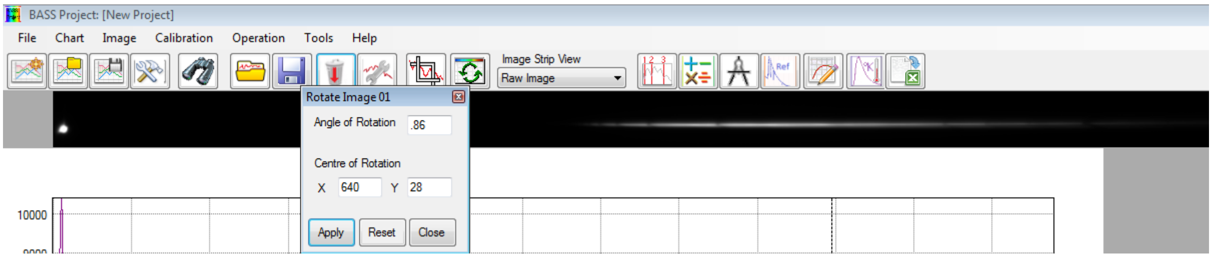
Reset – this button reverts the selected image to the previous (pre-rotated) state.

Close – this button closes the form.

Since the tilt angle will probably be unknown, it can be determined by trial and error by trying successive values and comparing with a rectangle selected around the spectrum.



Spectrum before rotation



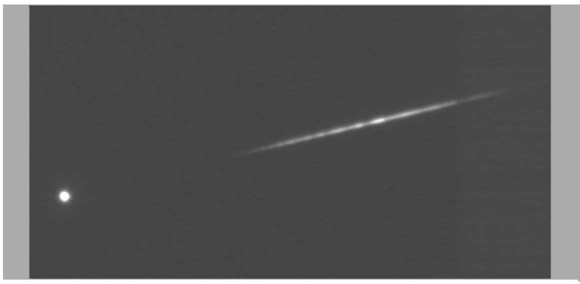
Angle of Rotation .86

Centre of Rotation

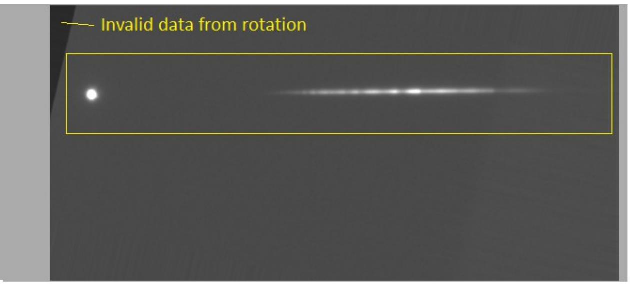
X 640 Y 28

Spectrum after rotation

Note: Geometric corrections such as rotation/tilt/smile can sometimes create some invalid pixels in one or more corners. In this case you would have to crop the image to avoid auto-scaling issues.



Before rotation

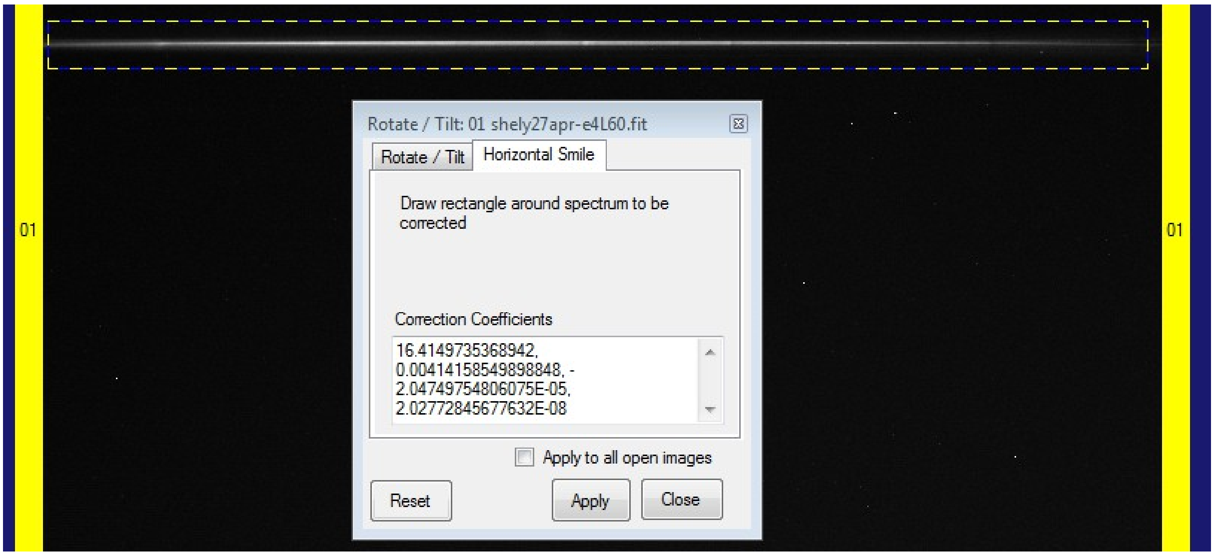


After rotation (crop to yellow box)

2.7.10.2 Horizontal Smile tab

This tab deals with the situation where the spectrum exhibits horizontal curvature that tilt or rotation alone cannot correct.

After drawing a rectangle, the smile correction coefficients are shown in the text area and applied when the Apply button is pressed.



Draw rectangle around spectrum to be corrected

```
16.4149735368942,
0.00414158549898848, -
2.04749754806075E-05,
2.02772845677632E-08
```

The coefficients can be copied and pasted to be applied to subsequent patches of images taken with the same setup.

2.7.11 Smile & Slant Correction

This allows a FITS image to be corrected for distortions where the spectral lines are curved or slanted relative to the axis of the spectrum. Enabled for 2D images only.

Smile is a curved distortion caused by misalignment within the optical configuration, (especially in Littrow spectrographs) and/or lens aberrations.

Slant is a distortion where the absorption lines are straight but are not perpendicular to the axis of the spectrum, (this differs from “tilt” where the spectrum direction is not aligned with the camera axis). Slant can also be created by trailing effects when using a slit-less configuration.

2.7.11.1 Automatic Smile & Slant Correction

The automatic option will scan a selected region for pixels having the minimum (or maximum) intensities to determine the correction required.

The correction process is as follows:

1. Open the FITS image to be corrected, ensure the Image Strip View is Raw Image

2. If necessary, rotate and or crop the image to remove any tilt.

3. Click the image to select it.

4. Open the Smile and Slant corrector screen form the main Image menu.

5. Using the mouse, select a rectangle around the most defined line.

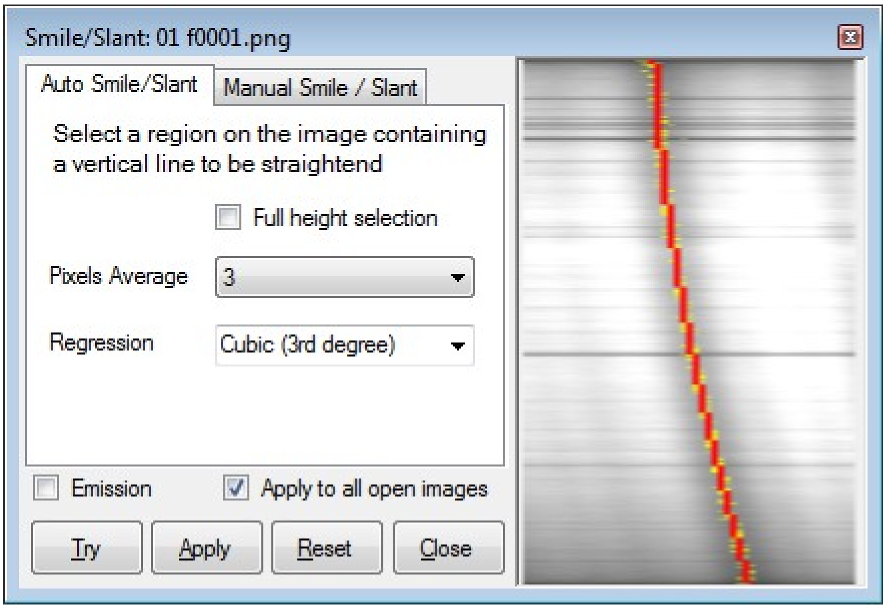
By default, the ‘Emission’ check box is ticked. Remember to un-tick it if working with an absorption type (dark) line.

6. Set ‘Pixels to Average’ at 3, leave Apply Best Fit as [none].

7. Press the Try button. This will draw a yellow curve that tracks the darkest (or brightest) pixels.

8. If the yellow curve is broken, experiment with the Average or select a better area on the image.

9. Select a Regression option to draw a red line or smooth curve. The Cubic (3rd degree) is normally fine.



Select a region on the image containing a vertical line to be straightend

☐ Full height selection

Pixels Average: 3

Regression: Cubic (3rd degree)

☐ Emission

☑ Apply to all open images

10. When the red line or curve fit looks good, press the Apply button to correct the selected image.

11. If the correction is not right, press the Reset button and repeat the process.

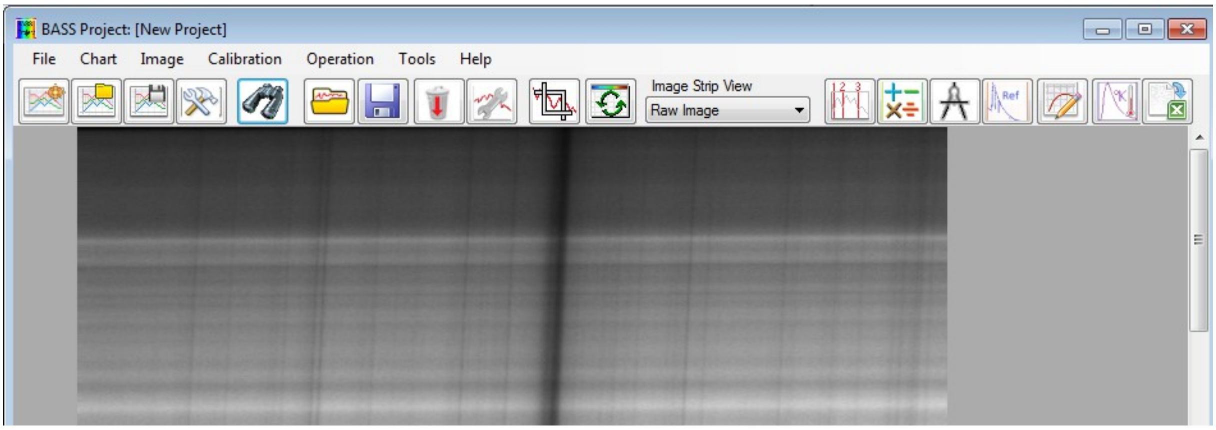
12. Only press the Close button when the correction is complete. The screen holds the original data until the screen is closed. Press the Reset button first if you wish to abort the correction.

Calibration should be performed after any tilt, smile or slant correction (as the *offset and dispersion will have been affected).*

2.7.11.2 Manual Slant Correction

The manual option will allow the user to either enter or draw the slant angle. The image is then corrected so that the slant angle is made vertical. For clarification, 0 degrees corresponds to a horizontal line.

1. Open the image to be corrected



Spectrum before slant removal

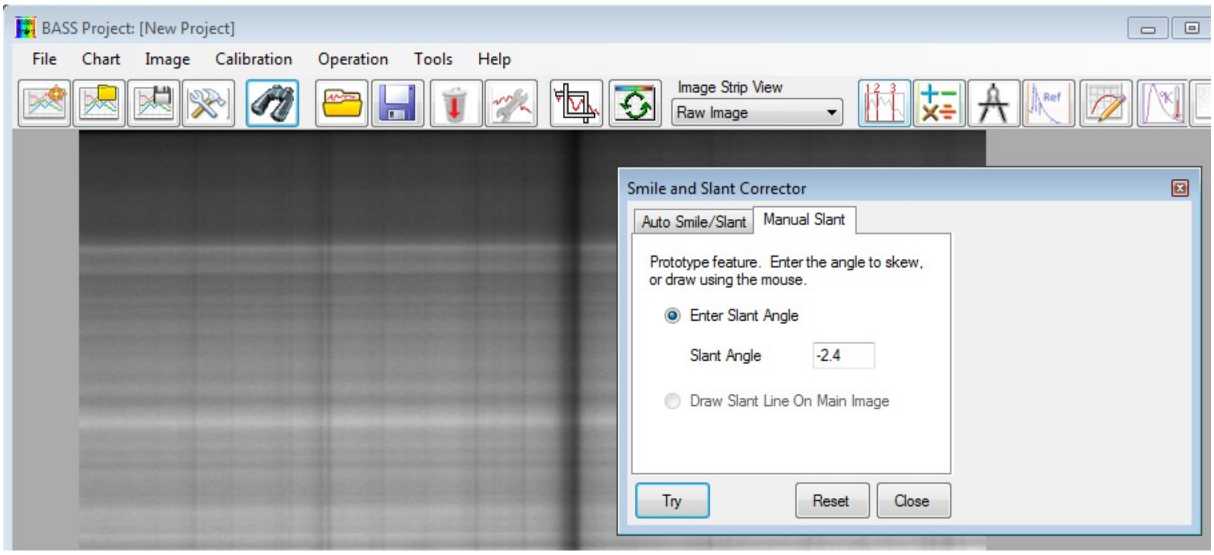
2. Open the Smile and Slant corrector screen form the main Image menu.

3. Click on the Manual Slant tab header

4. Specify the slant angle

If the slant angle is known
- Select the Enter Slant Angle option
- Key in the slant correction angle (in degrees) into the text box provided and press the Try button. (You can also change the angle using the spin up/down arrows or the arrow keys)

If the slant angle is unknown
- Select the Draw Slant Angle On Image option
- Use the mouse to draw a box around the feature to use for correction and press the Try button



Prototype feature. Enter the angle to skew, or draw using the mouse.

● Enter Slant Angle

Slant Angle: -2.4

○ Draw Slant Line On Main Image

Spectrum after slant removal

5. If necessary, edit the slant angle (by trial and error) and press the Try button until the lines are vertical

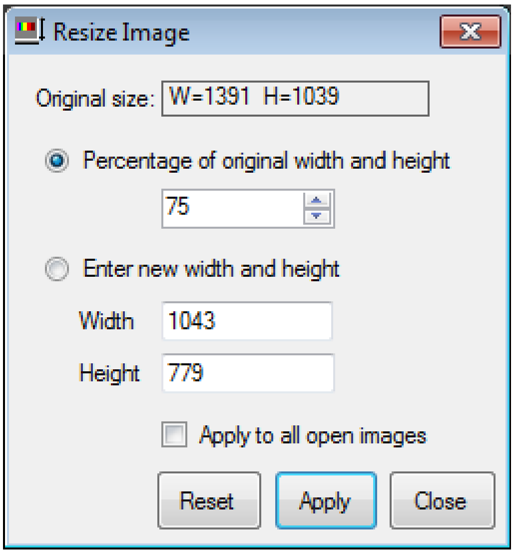
6. Only press the Close button when the correction is complete, or press the Reset button first if you wish to abort the correction.

2.7.12 Resize Image screen

This allows a selected two dimensional images image to be resized.

The resizing can be done either on a percentage basis (for both width and height), or by specifying new width and/or height values.

The 'Apply to all open images' option applies the new width and height values to all other open images.



Original size: W=1391 H=1039

● Percentage of original width and height

75

○ Enter new width and height

Width: 1043

Height: 779

☐ Apply to all open images

2.7.13 Normalise Flux Scale

The main use is for normalising the y-axis continuum value to "1".

The Normalisation Flux Scale screen (accessed from under the Image menu) has three tab headings.

- Normalise Continuum – Uses the average flux over a given wavelength range
- Absolute Flux – Convert flux to energy units

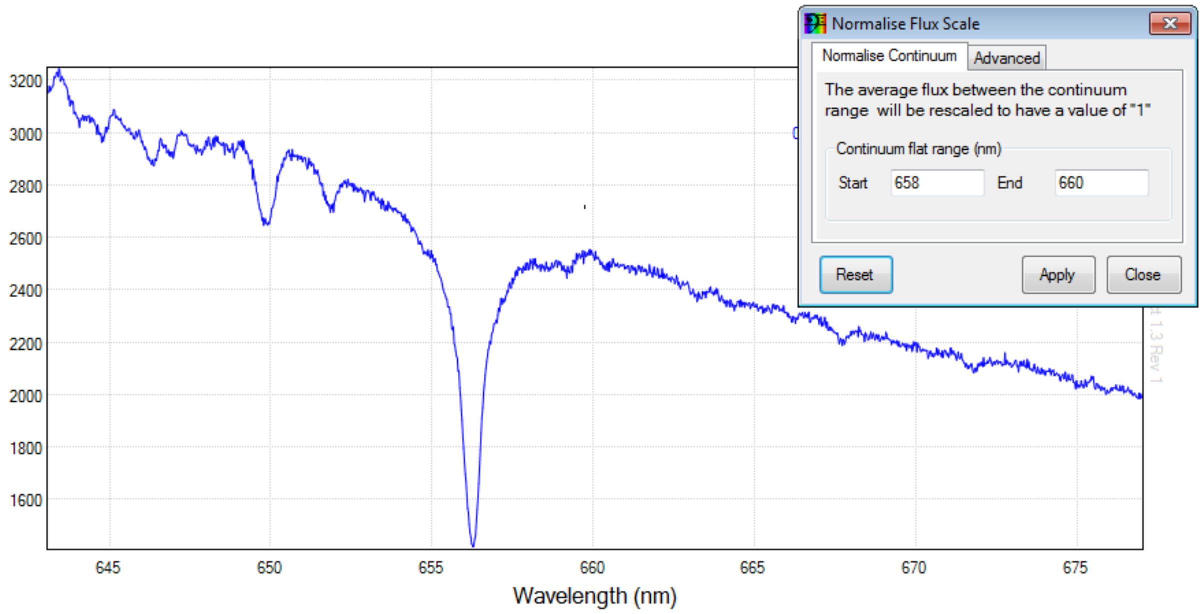
- Advanced – Rescales the y-axis to a target value using upper and lower flux values.

Important – the Y axis chart values are derived from the top (first) displayed profile. If you perform a flux normalisation, say on profile 2 or 3, then the change may not be visible (depending on y-axis profile settings).

2.7.13.1 Normalise Continuum tab

The Normalise Continuum tab will normalise the scale using the average value between the specified wavelength range.

The default range shown is taken from the Ranges tab of Chart Settings, but values can be overwritten if necessary.

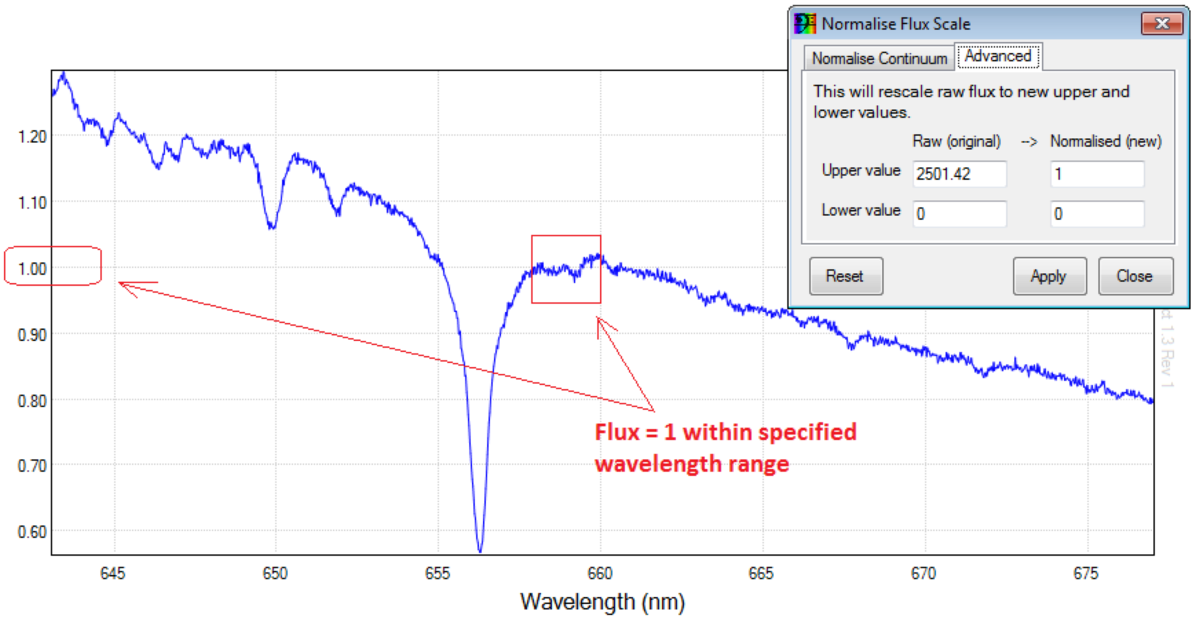


The average flux between the continuum range will be rescaled to have a value of "1"

Start 658 End 660

Click Apply to normalise the flux intensity to 1.

Note that the average flux between the specified range is populated in the Upper + Raw text box in the Advanced tab.



Flux = 1 within specified wavelength range

This will rescale raw flux to new upper and lower values.

	Raw (original)	--> Normalised (new)
Upper value	2501.42	1
Lower value	0	0

2.7.13.2 Absolute Flux tab

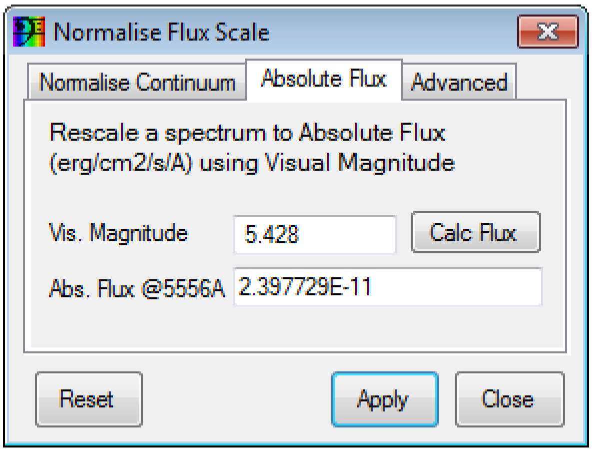
The Absolute Flux tab provides calculation of flux and scaling in energy units (erg/cm^2/s/A) at 5556A based on a known visual magnitude.

The Calc Flux button is used to calculate the Absolute flux at 5556 Angstroms using the following equation (as used in ISIS software).

$$F_a = 10^{-0.4 * V - 8.449}$$

Where F_a = absolute flux (erg/cm^2/s/A) at 5556A and V= visual magnitude

The Absolute Flux value is subsequently used to scale the chart when Apply is clicked.



Rescale a spectrum to Absolute Flux (erg/cm2/s/A) using Visual Magnitude

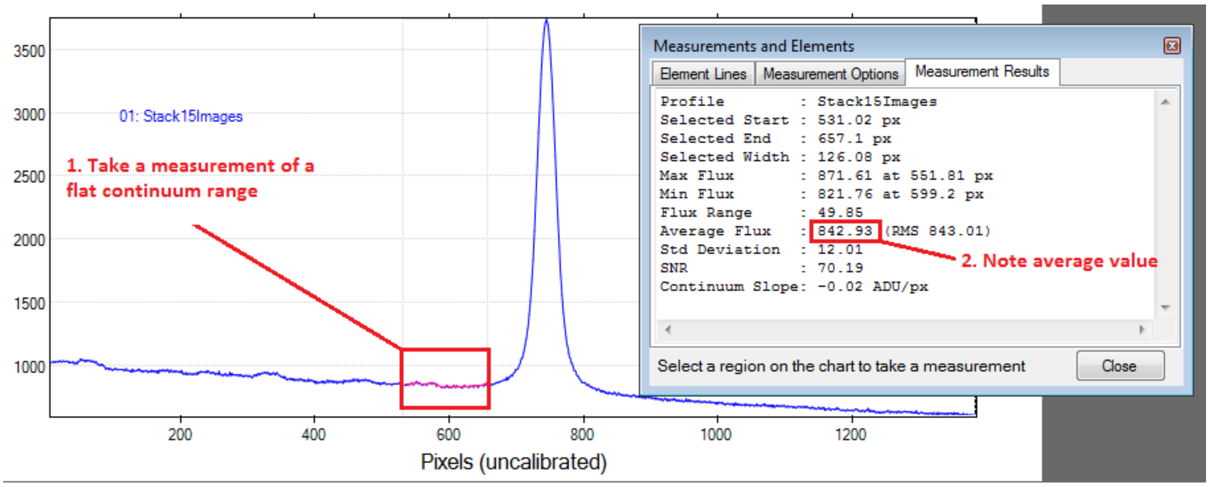
Vis. Magnitude 5.428

Abs. Flux @5556A 2.397729E-11

2.7.13.3 Advanced tab

The Advanced tab provides an alternative method for flux normalisation based on taking a measurement.

Follow the instructions provided in the screen shots below.

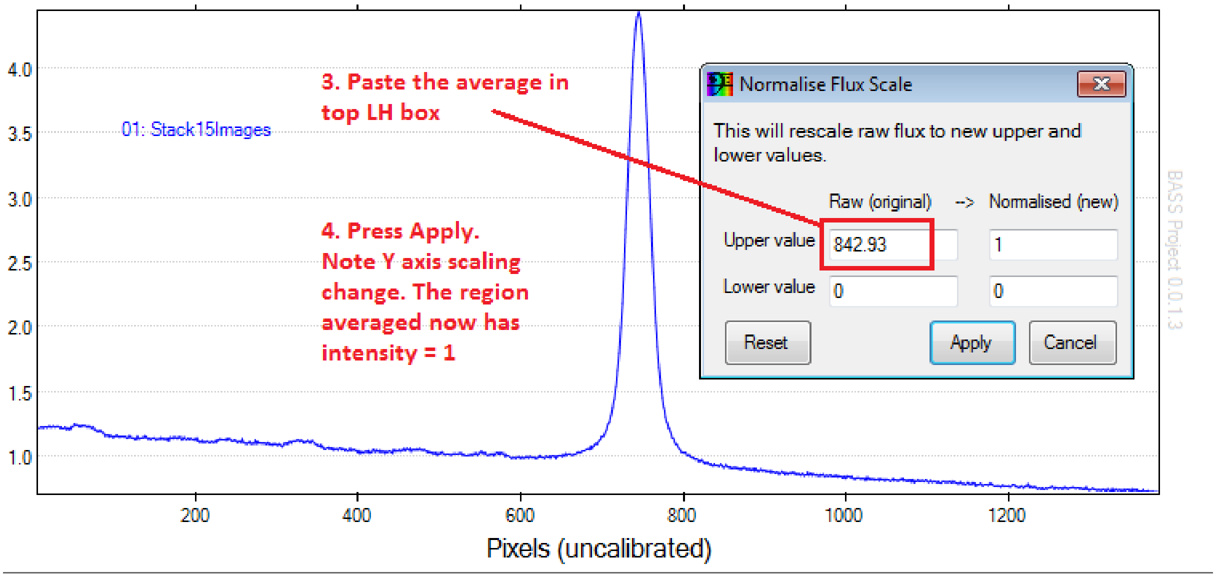


1. Take a measurement of a flat continuum range

```
Profile         : Stack15Images
Selected Start  : 531.02 px
Selected End    : 657.1 px
Selected Width  : 126.08 px
Max Flux        : 871.61 at 551.81 px
Min Flux        : 821.76 at 599.2 px
Flux Range      : 49.85
Average Flux    : 842.93 (RMS 843.01)
Std Deviation   : 12.01
SNR             : 70.19
Continuum Slope: -0.02 ADU/px
```

Select a region on the chart to take a measurement

2. Note average value



3. Paste the average in top LH box

This will rescale raw flux to new upper and lower values.

Raw (original) --> Normalised (new)

Upper value: 842.93 → 1

Lower value: 0 → 0

4. Press Apply. Note Y axis scaling change. The region averaged now has intensity = 1

If you want to normalise to a value other than “1”, overwrite “1” with your chosen value into Upper Normalised (New) textbox.

Press Reset to revert back to normal ADU scaling.

2.7.14 Edit Profile Flux Values

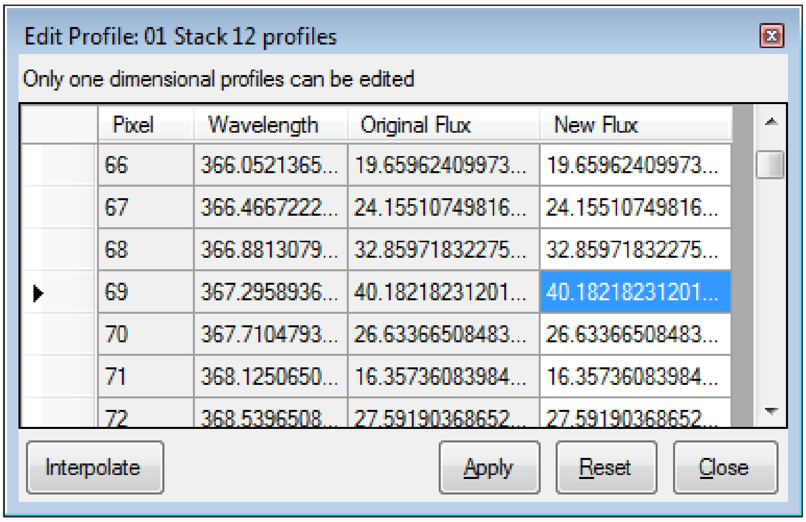
The Edit Profile Values screen is available under the Image menu and it allows profile flux values to be edited for one dimensional FITS profiles only. This functionality is intended to remove spurious data, such as from cosmetic or hot pixels when the original two dimensional image is no longer available.

This function is not intended for falsification of data!

The main part of the screen is a data grid containing the following columns

- Pixel – Read only column. Shows the pixel number
- Wavelength – Read only column. Shows the wavelength calculated for the given pixel. This is set to the pixel number if not calibrated
- Original Flux – Read only column. Shows the original (unedited) flux value
- New Flux – Editable column initially populated with original values

> *Note Scrolling the grid will synchronise the row with the cursor on the chart (so long as it is within the display bounds). In addition, clicking on the chart will synchronise the row that is displayed in the data grid. You can also zoom in using the X Axis crop too to make it easier to identify the pixel to edit.*



Edit Profile: 01 Stack 12 profiles

Only one dimensional profiles can be edited

	Pixel	Wavelength	Original Flux	New Flux
	66	366.0521365...	19.65962409973...	19.65962409973...
	67	366.4667222...	24.15510749816...	24.15510749816...
	68	366.8813079...	32.85971832275...	32.85971832275...
▶	69	367.2958936...	40.18218231201...	40.18218231201...
	70	367.7104793...	26.63366508483...	26.63366508483...
	71	368.1250650...	16.35736083984...	16.35736083984...
	72	368.5396508...	27.59190368652...	27.59190368652...

There are the following buttons on the bottom of the screen

- Interpolate – This button will prompt to replace the New Flux value for the selected pixel with an interpolated value using the previous and next original values. It is disabled for first and last rows.

- Apply – button will apply changes made and redraw the chart so changes are visible.

- Reset – button to undo changes and revert to the original data.

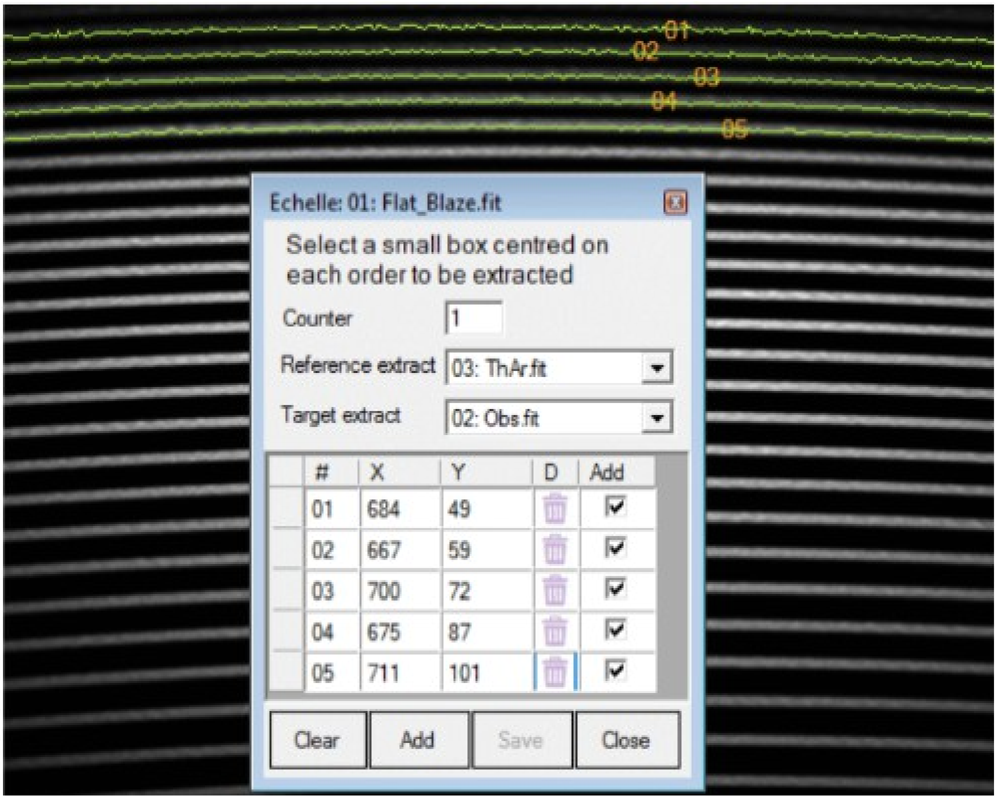
- Close – button to close the screen.

To make changes permanent, don't forget to save the profile after you have closed the screen.

2.7.15 Echelle Extraction

The screen is accessed from the Image menu > Echelle extraction.

An Echelle image typically captures multiple orders of spectra that are very often curved. Individual spectra need to be extracted and straightened before they can be reduced.



Echelle: 01: Flat_Blaze.fit

Select a small box centred on each order to be extracted

Counter: 1

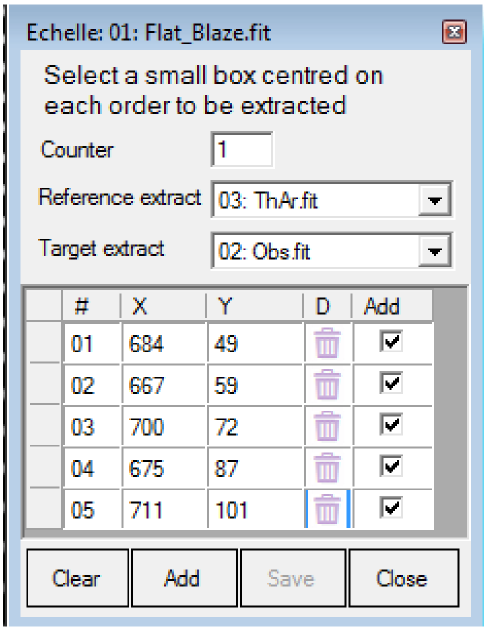
Reference extract: 03: ThAr.fit

Target extract: 02: Obs.fit

#	X	Y	D	Add
01	684	49	🗑	☑
02	667	59	🗑	☑
03	700	72	🗑	☑
04	675	87	🗑	☑
05	711	101	🗑	☑

The Echelle processing method allows multiple curved spectral orders to be extracted from a target Echelle image and its associated reference image in one operation.

The currently selected target image strip will be the target and is displayed on the screen caption.



Echelle: 01: Flat_Blaze.fit

Select a small box centred on each order to be extracted

Counter: 1

Reference extract: 03: ThAr.fit

Target extract: 02: Obs.fit

#	X	Y	D	Add
01	684	49	🗑	☑
02	667	59	🗑	☑
03	700	72	🗑	☑
04	675	87	🗑	☑
05	711	101	🗑	☑

Counter – A textbox used as the starting counter when naming the extracted orders. Default will be 1. You can enter a higher value; say 6, if you had already processed the first 5 orders in a previous session. A non-numeric input is interpreted as zero.

Reference Extract – A drop down list allowing you to select the reference calibration image that applies to the target. This creates additional image strips (see Add button).

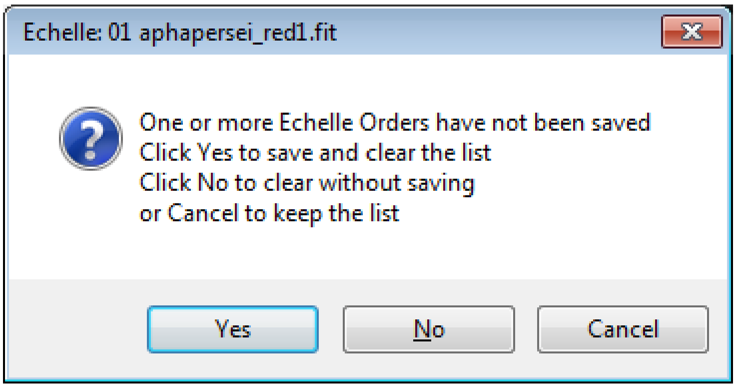
Target Extract – A drop down list allowing you to select the target (science) image. This creates additional image strips (see Add button).

Data Grid – A grid showing the Echell orders identified by a rectangle selected using the mouse. The grid will scroll and the screen can be resized to show more rows.

The grid columns are:

- # - the order number. This is equal to the row position and the Counter value. Read only
- X – centre X pixel value. Read only
- Y – centre Y pixel value Read only
- D – delete icon. Click to remove unwanted row (N.B. This does not remove the image strip, if already added).
- Add – checkbox. Ticked values create new image strips when the Add button underneath is pressed

Clear – button to remove data grid rows. You will be prompted to save new image strips. It will be easier to save multiple images before clearing the grid or closing the screen, (the alternative being to save one at a time later).



One or more Echelle Orders have not been saved
Click Yes to save and clear the list
Click No to clear without saving
or Cancel to keep the list

Add button
Use the Add button to create a set of straightened image strips for every grid row having 'Add' ticked. Once added, the tick is turned off to prevent duplicates

When a Flat image is used, it must be selected prior to the Echelle screen being opened. The Reference Extract is then mapped to the calibration image and the Target Extract mapped to the science image. If no Flat image is used, the science image is selected prior to the Echelle screen being opened.

Note: Using a flat image has the benefit of being able to extract spectra that don't have a strong continuum.

Each new image from the target will have a default caption (& filename) consisting of <*OriginalTargetName*> + '_ECH_' + <#> . Where <#> is an incrementing counter that uses the number entered into the textbox. E.g. BetaLyr_**ECH**_04

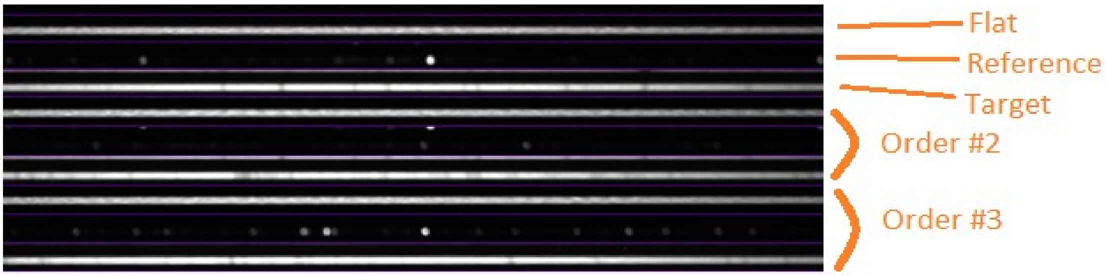
Each new image from the reference or flat image will use a slightly different naming <*OriginalTargetName*> + '_ECH_REF_' + <#> E.g. BetaLyr_**ECH_REF**_04

Save button

The Save button is enabled after one or more orders have been extracted. It is used to save all new image strips to disc in the same location as the target image. The file naming convention will be as stated above.

Close – button to exit screen. You will be prompted to save new image strips (as per Clear button).

The photo below shows an extract of three spectral orders where flat and reference images were provided.

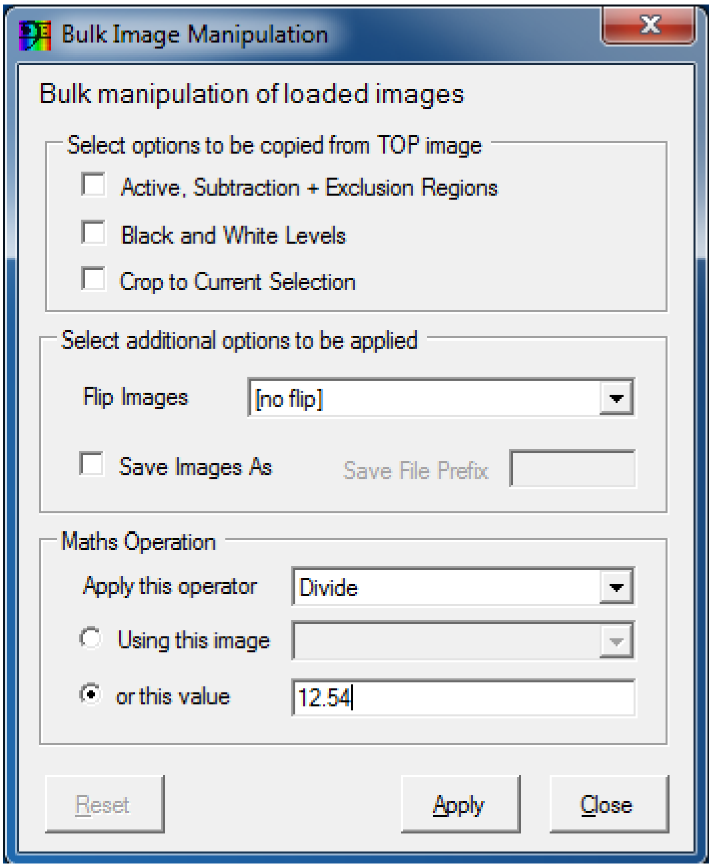


Please refer to the Echelle tutorial document link below for more details, but note that the it was written before the ability to use flat echelle images was added.
https://www.dropbox.com/s/28hh659jkff3wb2/BASS%20Echelle%20Processing%200_4.pdf?dl=0

2.7.16 Bulk Image Manipulation screen

This allows image processing and manipulation to be applied to multiple images. For example, all images can be flipped from left to right and be set to the same active and background regions, and/or black and white levels. This functionality is intended primarily for a small number of slit spectrometer images that don't require alignment. Enabled for 2D images only.

It is recommended that you are familiar with executing image processing on individual images before processing images in bulk. In addition, the processing applied to multiple images must be appropriate e.g. the images should be of the same target and configuration



Select options to be copied from TOP image

☐ Active, Subtraction + Exclusion Regions
☐ Black and White Levels
☐ Crop to Current Selection

Select additional options to be applied

Flip Images [no flip]
☐ Save Images As Save File Prefix

Maths Operation

Apply this operator Divide
○ Using this image
● or this value 12.54

> *Note: There is a finite limit on the number of images that can be processed before you see 'out of memory' error messages. Large DSLR or CCD images may need to be cropped or processed in smaller batches.*

The screen contains the following features

- Active and Background Regions - ticking this checkbox will copy active and background region settings from the top image to all open images.

- Black and White levels – ticking this checkbox will apply the black and white levels from the top image to all open profiles

- Crop to Selection – this will crop all open images using the current selected rectangle on the top image.

- Flip Left to Right – this will flip all open images from left to right (mirror image).

- Save Images As – this will save all images within the project with a new filename constructed using a prefix in front of the original filename.

  This is useful when you need to save separate copies of file, say that had been cropped and/or rotated etc. The project is immediately updated to use the new filenames.

  New images must be saved beforehand. Any prefixed filename that already exists will be overwritten without warning.

Note. Take care not to run multiple times as the filenames will also be prefixed multiple times and you will get more versions. If you need to redo, it may be better to close the project and reload the original images.

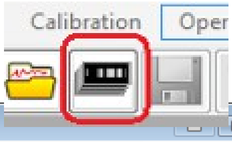
- Maths Operation –. Allows a two dimensional maths operation (e.g. divide all open images by one flat image), so long as all images are the same size. Useful for applying a flat for Spectro-Heliograms. Do not confuse this with the existing one dimensional maths operations function that acts on profiles
- Reset – button to undo changes applied when Apply was pressed
- Apply – button to apply changes to all open images
- Close – close the screen

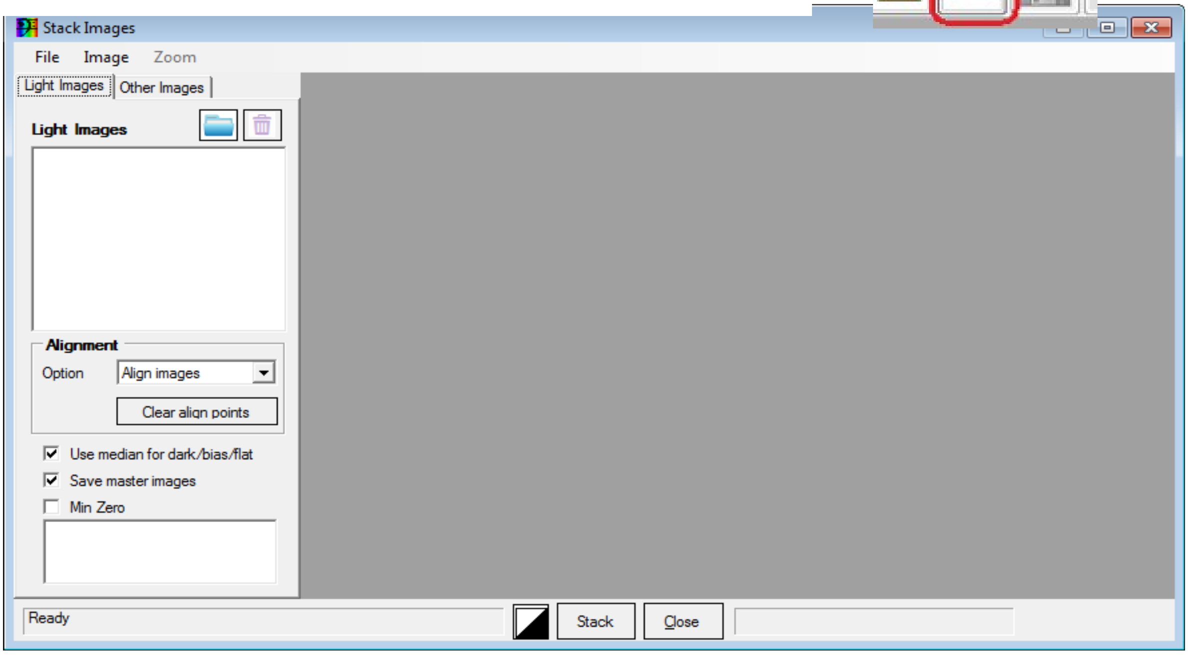
Note that Crop to Selection cannot be used at the same time as Active and Background Regions. Crop the images before setting active and background regions.

2.8 Stack Images

A Stack Images screen is provided to provide stacking and alignment of images to improve the signal to noise ratio. (Not to be confused with functionality for stacking and alignment of one dimensional profiles).

The Stack Images screen is accessed via a toolbar icon or the main File menu.





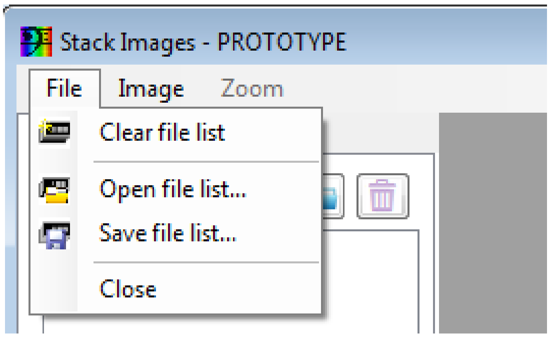
Option: Align images

☑ Use median for dark/bias/flat
☑ Save master images
☐ Min Zero

2.8.1 File Menu

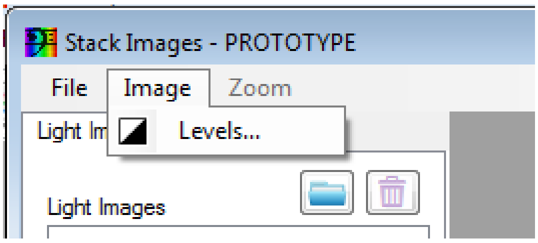
The Stack Images File menu includes the following options.

This allows the list of files and settings to be saved and loaded. A default file extension of “*.stk” is used. The file format is tab delimited text.



2.8.2 Image Menu

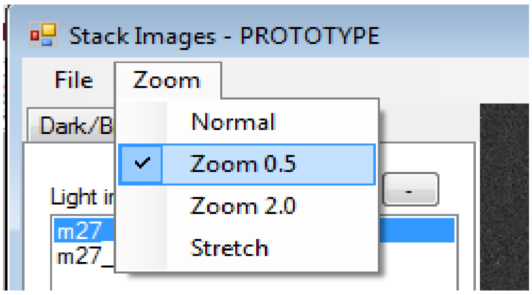
The Image menu provides a Black & White Levels option



2.8.3 Zoom Menu

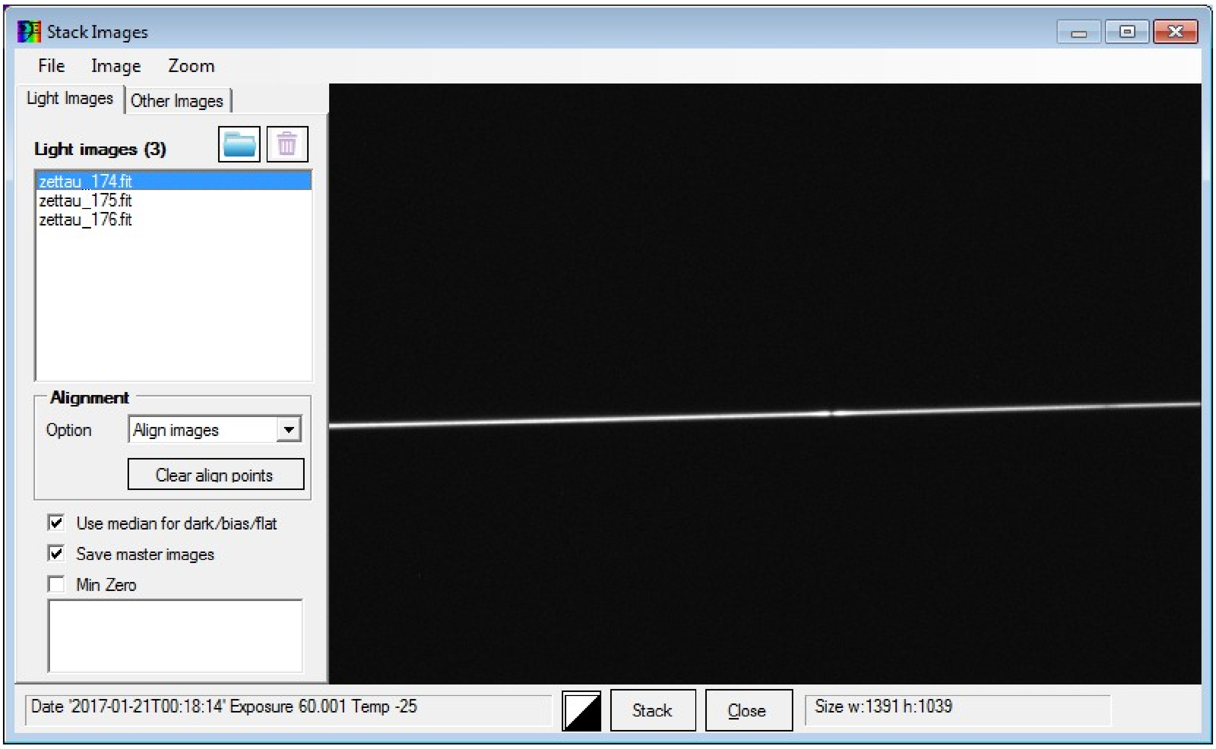
The Zoom menu is only enabled when an image in a list box is selected.

The zoom options allow the selected image to be viewed at a different scale.



2.8.4 Light Images tab

The first tab header allows the light images to be loaded for stacking.



Light images (3)

zettau_174.fit
zettau_175.fit
zettau_176.fit

Alignment

Option: Align images

☑ Use median for dark/bias/flat
☑ Save master images
☐ Min Zero

Date '2017-01-21T00:18:14' Exposure 60.001 Temp -25

Size w:1391 h:1039

To load images press the Folder button and select one or more files from a Windows file dialog.

Clicking on a file from the LH list box displays the image on the right as well as info. In the LH status bar.

To remove images files, highlight one or more files in the list box and press the Remove button

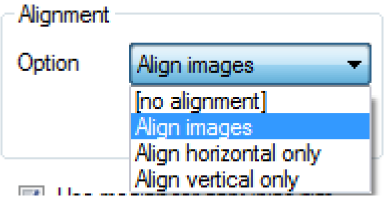
*Note – If the Shift key is held down when the Remove button is pressed then an option will appear allowing the actual files (and associated BASS image information file *.info.bas files) to be deleted.*

Where possible, local files are moved to the PC Recycle Bin, (but will not be recoverable if the recycle bin is disabled, full or if the files are on a network drive).

Selecting each file item in the list in turn, allows a basic examination of each file with an end to rejecting lower quality images. If necessary, use the black and white levels icon (next to the Stack button) to make images easier to view.

2.8.5 Image Alignment

An alignment option drop down list is provided.

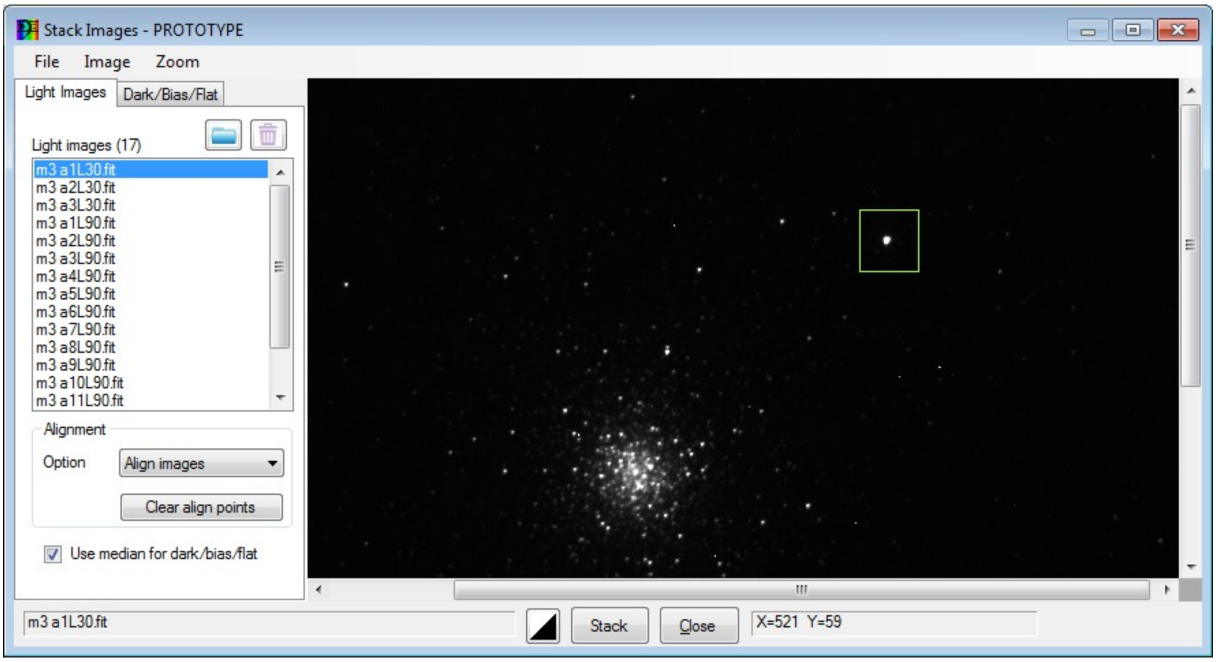


The options are:

- No alignment – images are stacked without any alignment. (Normal for slit-spectrometer spectral images).
- Align images – aligns images in horizontal and vertical directions. This is the default option
- Align horizontal only* – images are only aligned in the horizontal direction
- Align vertical only* – images are only aligned in the vertical direction

** Experimental settings for spectral processing only*

If alignment is required, select the first image in the list of light images and then select a rectangle around a feature to be used for alignment (the ‘Zero Order’ normally works well enough for a slit-less grating image). The selection should be of sufficient size to encompass the same feature in subsequent images. If this is not possible, because other brighter features would be picked up, then individual selections of the feature can be specified per image.



Light images (17)

m3 a1L30.fit
m3 a2L30.fit
m3 a3L30.fit
m3 a1L90.fit
m3 a2L90.fit
m3 a3L90.fit
m3 a4L90.fit
m3 a5L90.fit
m3 a6L90.fit
m3 a7L90.fit
m3 a8L90.fit
m3 a9L90.fit
m3 a10L90.fit
m3 a11L90.fit

Option: Align images

☑ Use median for dark/bias/flat

m3 a1L30.fit

X=521 Y=59

To remove alignment information, click the ‘Clear align points’ button.

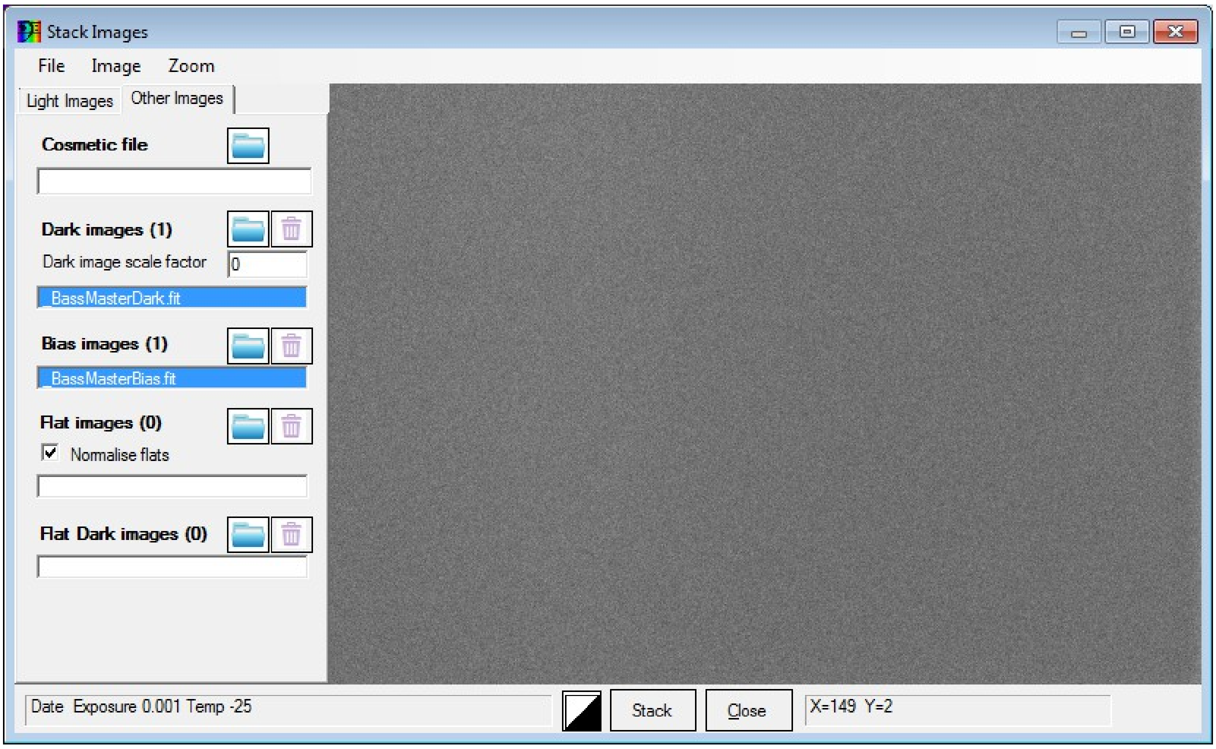
> *Note: If alignment is necessary but cannot be achieved due to a lack of point features, then another possibility is to process frames individually and use the Stack and Align Profiles functionality under the Operations main menu.*

If Dark, Bias, Flat and or Flat Dark images were taken, click on the second tab header and load (see next section).

> *Note – A globular cluster image is shown in this example, but the images could also be from a slit-less Star Analyser type grating or a slit spectrometer.*

2.8.6 Other Images tab

The second tab header provides sections on left hand side to allow Dark, Bias, Flat and/or Flat Dark images to be loaded or removed. Selecting a file from a list box displays the image on the right.



Cosmetic file

Dark images (1)

Dark image scale factor 0

BassMasterDark.fit

Bias images (1)

BassMasterBias.fit

Flat images (0)

☑ Normalise flats

Flat Dark images (0)

Date Exposure 0.001 Temp -25

X=149 Y=2

To load files press the Folder button and select one or more from a Windows file dialog.

To remove files, highlight one or more files and press the Remove button

*Note – If the Shift key is held down when the Remove button is pressed then an option will appear allowing the actual files (and *.info.bas files) to be deleted.*

Files in the second tab are not mandatory. Where multiple files are provided, the system will generate a ‘master’ on the fly that has data combined by median or arithmetic mean (defined in the first tab header).

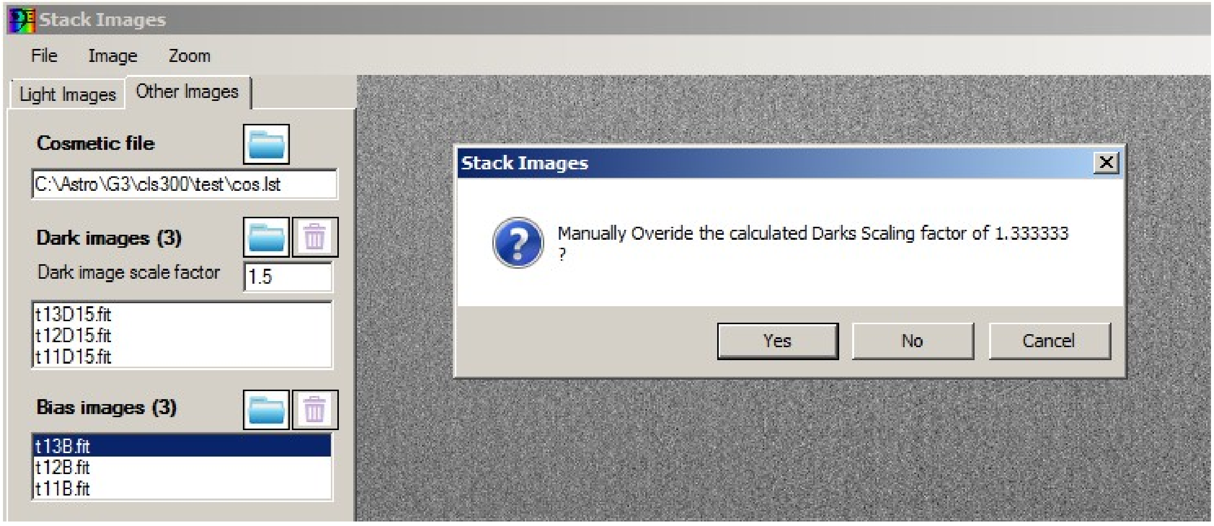
The Cosmetic File section allows a single cosmetic file, (see Cosmetic, Hot & Cold pixel section), to be loaded. The Cosmetic file will be applied to all images specified in Light and Other Images tabs.

Dark Image Scale Factor

Scaling of dark image frames allowing pre-processing to use dark frame images having exposure times not equal to light exposures, so long as dark and bias images are provides and EXPTIME is populated in the FITS header. If no EXPTIME keyword exists in the FITS header (e.g. if frames are RGB files such as jpeg), a textbox is provided to enter a manual light/dark exposure scaling factor.

For example if your light images have a 60 second exposure but your dark images are 40 second, you enter a factor of (60/40) = 1.5.

When a value > 0 is entered into the dark scale factor checkbox, you are prompted before stacking is run, to confirm if the calculated or manual scaling value should be used.



Cosmetic file: C:\Astro\G3\cls300\test\cos.lst

Dark image scale factor: 1.5

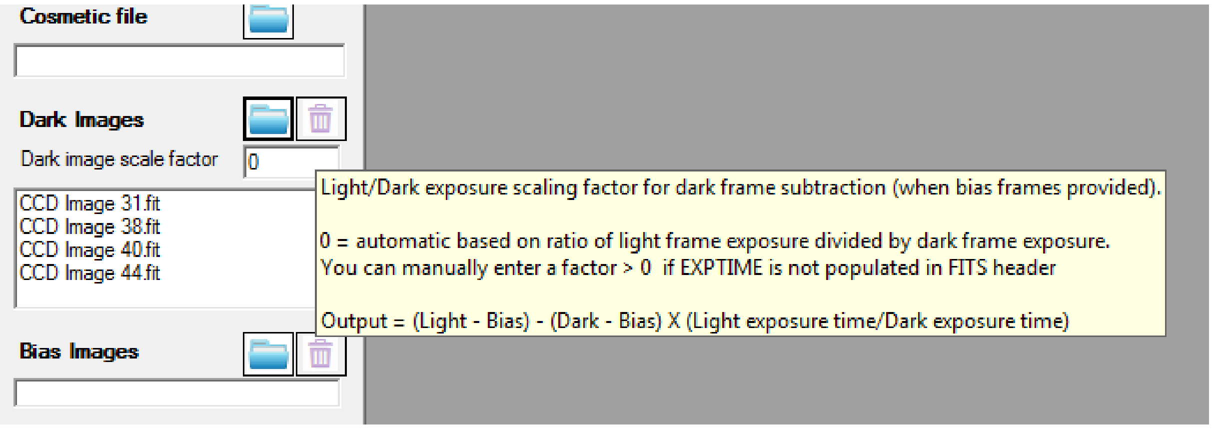
t13D15.fit
t12D15.fit
t11D15.fit

t13B.fit
t12B.fit
t11B.fit

Manually Overide the calculated Darks Scaling factor of 1.333333 ?

- Yes – use the manually input factor (1.5 in example above)
- No – use the calculated value based on FITS header (e.g. 1.333)
- Cancel - abort without stacking

The tooltip information in the screenshot below provides a reminder of the purpose of the textbox.



Dark image scale factor: 0

CCD Image 31.fit
CCD Image 38.fit
CCD Image 40.fit
CCD Image 44.fit

Light/Dark exposure scaling factor for dark frame subtraction (when bias frames provided).

0 = automatic based on ratio of light frame exposure divided by dark frame exposure.
You can manually enter a factor > 0 if EXPTIME is not populated in FITS header

Output = (Light - Bias) - (Dark - Bias) X (Light exposure time/Dark exposure time)

2.8.7 Stacking Process

Pressing the Stack button will initiate processing as follows:

1. Validate that one or more Light images are loaded
2. Validate that an alignment region is set for at least the first image (only if an Align Images option is selected)
3. Apply cosmetic file (if exists) to all Dark, Bias, Flat and/or FlatDark images.
4. Aggregate Dark images (if exist)
5. Aggregate Bias images (if exist)
6. Aggregate Flat images (if exist) and normalise to nominal 1 if option ticked.

7. Aggregate Flat Dark images (if exist)
8. Each Light image frame is then processed to:
    a. Apply cosmetic file (if exists)
    b. Subtract the master Bias value from the Light value (if Bias frames exist)
    c. Subtract the master Dark value (if exist) minus the Bias value (if bias frames exist). This allows for scaled darks that have an exposure time that differs from the Light images. If exposure times match then Bias subtractions cancel out.
    d. Divide by the master Flat value minus the Flat Dark master value (if exist) or the Bias value.
    e. The pixel position is adjusted such that Light frame values are stacked accordingly (if alignment enabled).
9. The result creates a new FITS image that is loaded into the main BASS Project chart for subsequent background removal, calibration etc. Set the Image Strip View to raw image to see the stacked result.
10. The FITS header keywords, DATE-OBS, DATE-END and EXPTIME, are populated to show the start and end date & times of image acquisition. EXPTIME shows the time in seconds, between the end of the last image and the start of the first (not the camera exposure time).
11. A comment is added to the FITS header that shows the number of image frames used

Note: A Flat Dark frame is a dark frame that is taken with the same exposure time used to capture the Flat frames. The Flat Dark takes precedence over the Bias. This means the Flat Dark is subtracted from the Flat. The Bias is then only used with the Light and Dark frames.

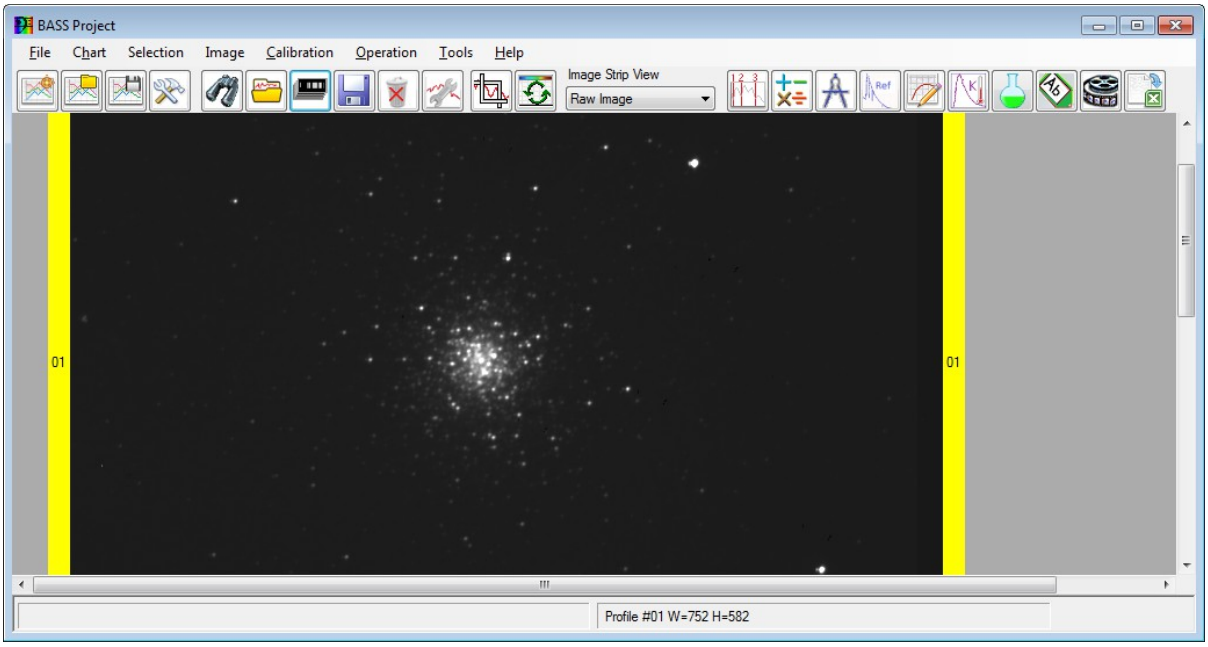
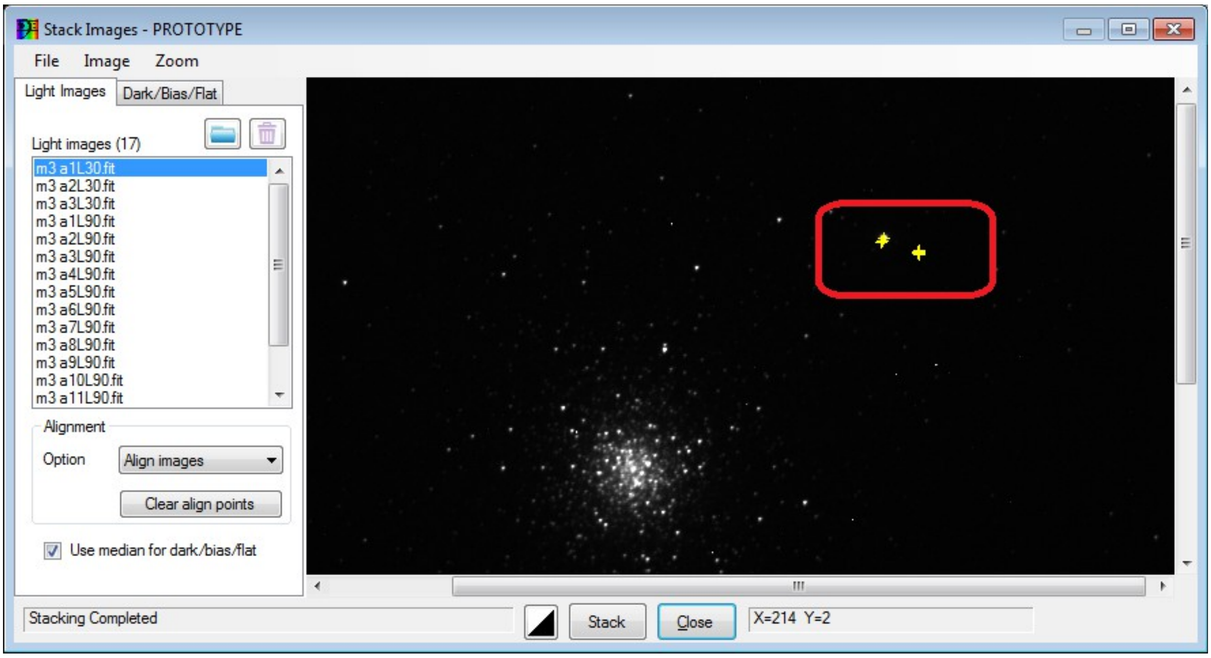


Image Strip View: Raw Image

Profile #01 W=752 H=582

You can open the Stack Images screen again to review and restack if necessary. Notice that there will be yellow "+" at each detected alignment point.



Light images (17)

m3 a1L30.fit
m3 a2L30.fit
m3 a3L30.fit
m3 a1L90.fit
m3 a2L90.fit
m3 a3L90.fit
m3 a4L90.fit
m3 a5L90.fit
m3 a6L90.fit
m3 a7L90.fit
m3 a8L90.fit
m3 a9L90.fit
m3 a10L90.fit
m3 a11L90.fit

Option: Align images

☑ Use median for dark/bias/flat

Stacking Completed

X=214 Y=2

Note: The Stacking mechanism is intended for spectroscopic use. It therefore does not provide astronomical image processing functionality such as curves and layering.

In addition, there is an assumption that only a relatively small number of images will be stacked (up to 50 depending on image size).

2.9 Stack and Align Profiles

Stacking profiles averages a set of one dimensional image profiles to create an average of the profiles, usually in order to improve the signal to noise ratio.

See also the Stack Images section to stack and align two dimensional images.

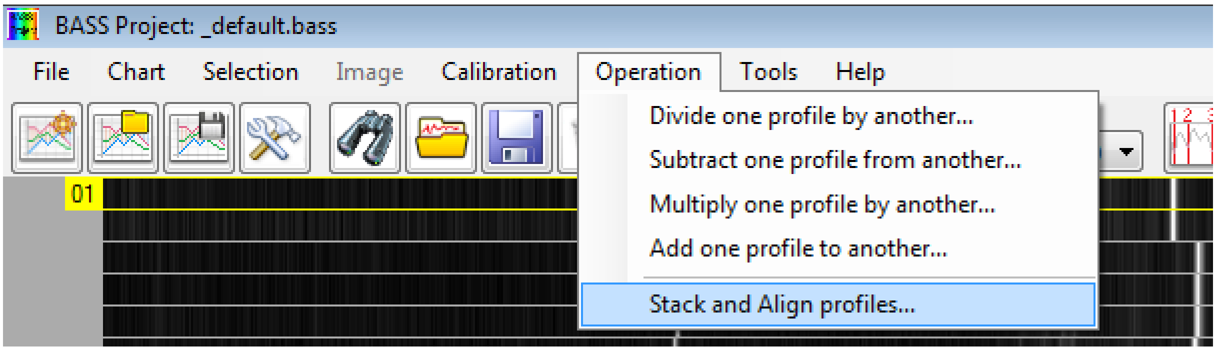
The Stack and Align profiles screen, accessible from the Operations menu, allows one dimensional profiles to be stacked, aligned or aligned and stacked.

Here is a high level process to align & stack multiple profiles

- Load multiple spectra (10 in this case). These were unguided so positions of spectral lines vary in each spectrum.

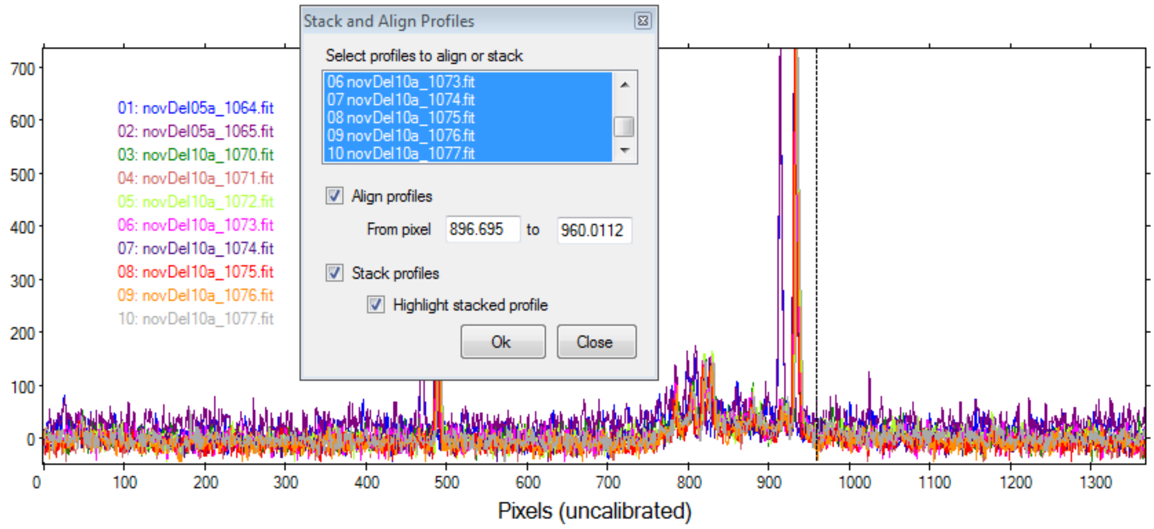
- Before aligning & stacking you would need to apply geometric (corrections if required) and the set the binning and background subtracted regions of each profile. This can be done using the Region Selection Tool and Bulk Image Manipulation screen functions.

- Open the Stack and Align screen from the Operation menu



- The Stack and Align screen provides a list box to allow individual profiles to be selected. All are selected by default. Remember to unselect any you don't want to be included.

NB it is recommended that you reopen this screen if profiles are added or removed while this screen is open, otherwise the list of profiles may not be up to date.


Stack and Align Profiles

Select profiles to align or stack

06 novDel10a_1073.fit
07 novDel10a_1074.fit
08 novDel10a_1075.fit
09 novDel10a_1076.fit
10 novDel10a_1077.fit

☑ Align profiles

From pixel 896.695 to 960.0112

☑ Stack profiles

☑ Highlight stacked profile

- Tick the Align checkbox and then either manually key in or use the mouse on the chart to select a pixel range on the chart that covers the feature to be aligned. In this example we are using the Hydrogen Alpha peaks between 897 and 960 pixels.

- Tick the Stack and Highlight checkboxes.

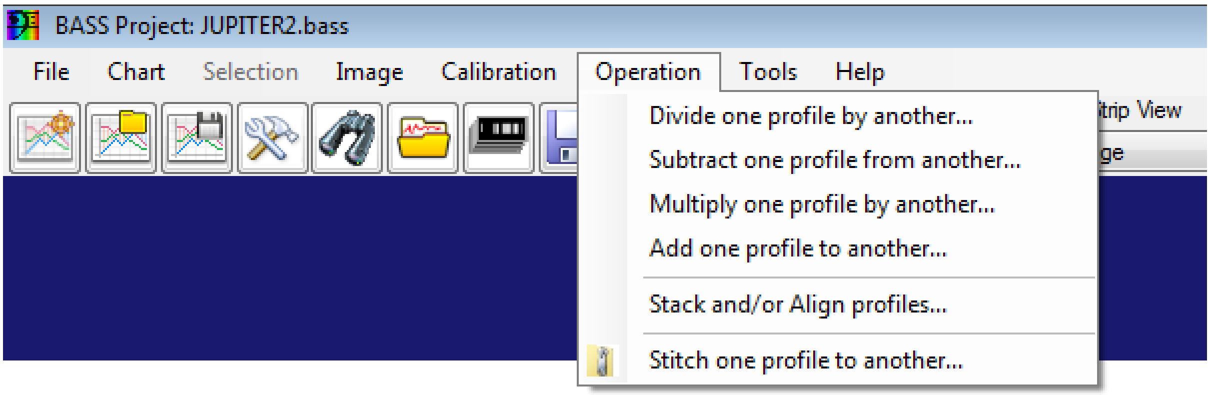
- Press the OK button and then OK in the confirmation dialog box. The screen will close, profiles will be aligned and a new stacked profile #11 is created.

The format of new profiles created will be either FIT or DAT depending on the format of the first selected profile.

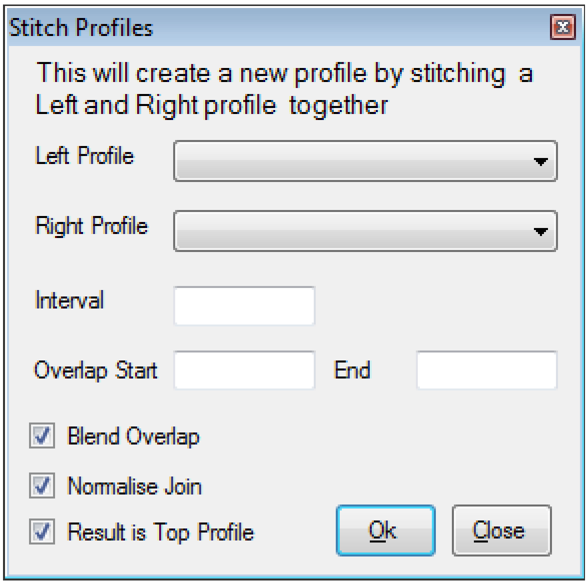
2.10 Stitch Profiles

The Stitch Two Profiles screen is accessed via the “Operation” -> “Stitch one profile to another” menu and will allow two or more profiles to be stitched (joined) together to create a single profile having wider wavelength coverage.

The stitching will work on calibrated and un-calibrated source profiles. The basic principle is to stitch together profiles one at a time from left to right.



The screen provides the following functionality



This will create a new profile by stitching a Left and Right profile together

☑ Blend Overlap

☑ Normalise Join

☑ Result is Top Profile

Left Profile – A drop down list of loaded profiles. Use this to select the first profile to stitch. The Left profile should have shorter wavelengths that the Right.

Right Profile – A drop down list of loaded profiles. Use this to select the second profile to stitch. The Right profile should have longer wavelengths that the Left.

Interval – The sampling interval of the stitched result. The default value is taken from the Left profile or will be “1” if not calibrated.

Overlap Start – The start wavelength (or pixel if not calibrated) of the overlap. This defaults to the starting wavelength of the Right profile. It can be beneficial to restrict the Overlap Start and Overlap End range to a small flat region.

Overlap End – The end wavelength (or pixel if not calibrated)of the overlap. This defaults to the end wavelength of the Left profile.

Blend Overlap – A checkbox. When ticked will average the Left & Right profile values between Overlap Start and Overlap End.

Normalise Join – A checkbox. When ticked will scale the flux of the Right profile to match that of the Left, at the Overlap Start position. Turn this off is you have already normalised the scaling.

Result is Top profile – A checkbox. When ticked will promote the stitched profile to be the top profile. This will cause the chart scale to include the full wavelength span of the Left & Right profiles. The stitched profile can be selected as the Left profile to be joined to another Right profile having an even longer wavelength start range.

OK – A button to stitch the Left and Right profiles together uses the above settings. The caption of each new stitched profile will be Stitch 01, Stitch 02 etc.

Use ‘Save As 1D’ to preserve calibration information when saving the new profile.

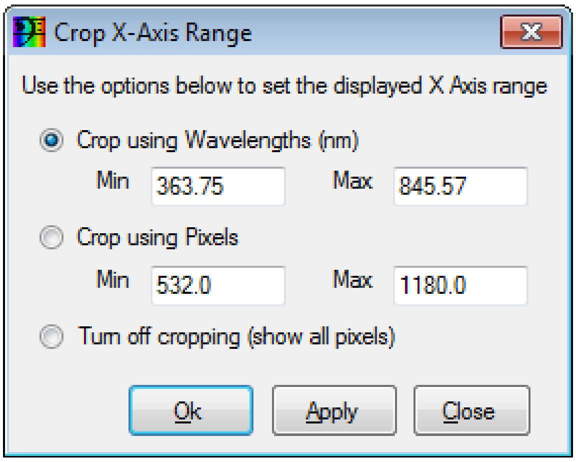
Cancel – A button to close the form.

The checkbox options are all “on” by default and should work well for most scenarios.

2.11 Crop X-Axis Range

This function is available from the toolbar or Chart menu.

This allows you to zoom in on a region by setting the start and end x-axis display values. This is a very important feature since the chart will auto-scale the y-axis based on the x-axis range, (y-axis scaling can also be manually adjusted if necessary).


Crop X-Axis Range

Use the options below to set the displayed X Axis range

● Crop using Wavelengths (nm)

Min 363.75 Max 845.57

○ Crop using Pixels

Min 532.0 Max 1180.0

○ Turn off cropping (show all pixels)

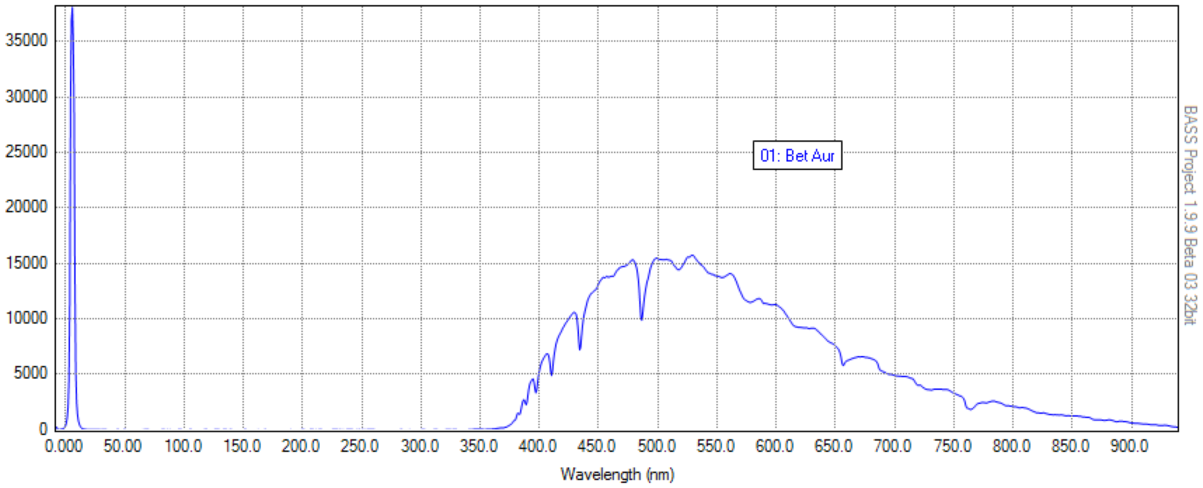
For clarification, this feature only affects the range of pixels or wavelengths displayed; it does not permanently 'crop' the profile.

The three radio buttons offer the choice of cropping using wavelength, pixels and for cancelling crop to show the entire profile.

The wavelength radio button and min max boxes will only be available (enabled) when the top profile is calibrated

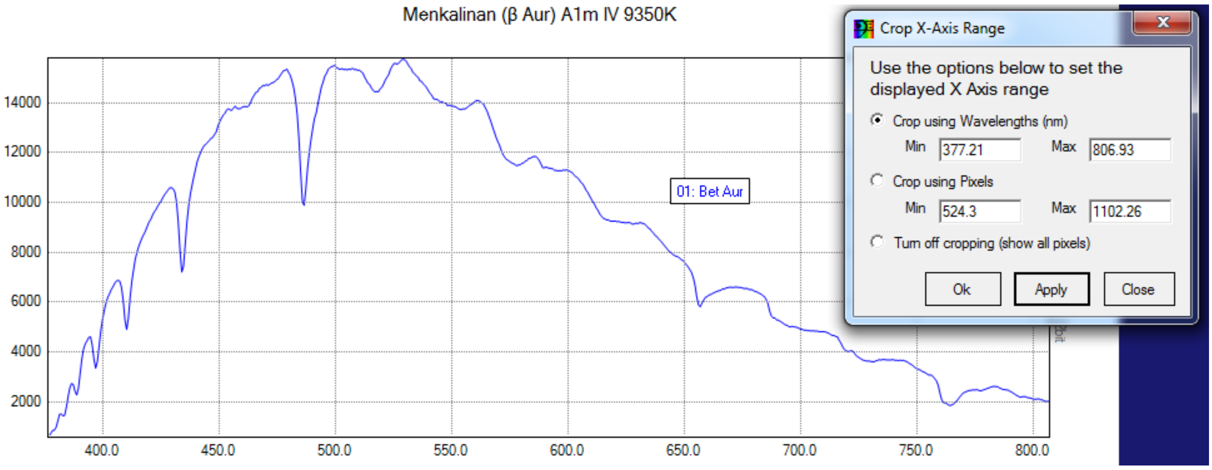
2.11.1 Zoom in

To zoom in on a region within the existing chart, first select the range using the mouse, holding down the left mouse button, before clicking on the Crop X-axis icon.



The Min and Max values are pre-populated using the range selected prior to clicking the icon. Once the screen is displayed, you can edit the text boxes if necessary, before clicking on OK or Apply.

The entire chart area is then filled with the cropped region.



Use the options below to set the displayed X Axis range

● Crop using Wavelengths (nm)
Min 377.21 Max 806.93

○ Crop using Pixels
Min 524.3 Max 1102.26

○ Turn off cropping (show all pixels)

You can continue to make selections and zoom in further.

The textboxes are validated to restrict inputs to the maximum or minimum allowed pixel or wavelength values. E.g. if the image is 1391 pixels wide and you try to enter 9999 then 1391 will be displayed.

2.11.2 Zoom out

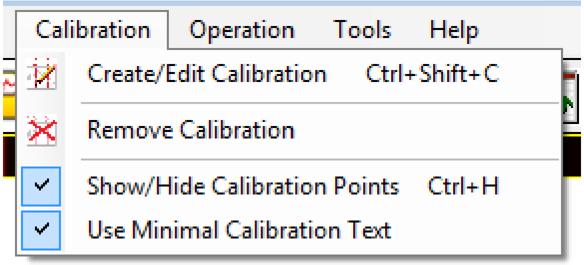
To zoom out again either click on the Turn Off Cropping radio button, or specify wider Min and Max wavelength or pixel values.

2.12 Wavelength Calibration

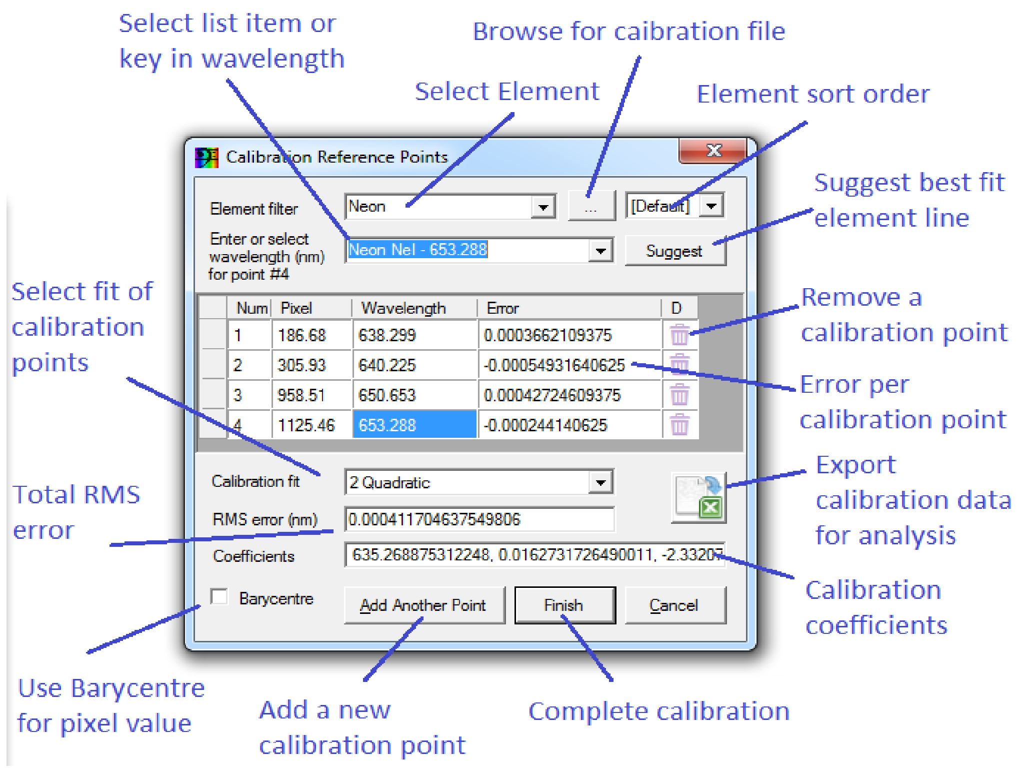
Wavelength calibration (also known as spectral calibration) is the process to allow the profile to be presented using wavelength along the x-axis (rather than pixel). It normally involves identifying two or more features where the wavelength is known.

> *Note: BASS uses nanometers (nm) as the default unit of wavelength, but this can be easily changed to Angstroms or microns (in Chart Settings see 2.2.7).*
>
> *The conversion is 1nm = 10 Angstroms = 0.001microns*

The functionality to calibrate a spectral profile is accessed by the main Calibration menu. Calibration data is saved to the ".info.bas" image information file that shadows the profile or image being calibrated. This is able to store multiple order calibrations as well as the actual calibration data points (which are not normally stored in FITS files).



The screen functionality is shown in the annotated screen image and described below.



Element filter: Neon

[Default]

Enter or select wavelength (nm) for point #4: Neon NeI - 653.288

Num	Pixel	Wavelength	Error
1	186.68	638.299	0.0003662109375
2	305.93	640.225	-0.00054931640625
3	958.51	650.653	0.00042724609375
4	1125.46	653.288	-0.000244140625

Calibration fit: 2 Quadratic

RMS error (nm): 0.000411704637549806

Coefficients: 635.268875312248, 0.0162731726490011, -2.33207

☐ Barycentre

Select list item or key in wavelength

Browse for caibration file

Select Element

Element sort order

Suggest best fit element line

Select fit of calibration points

Remove a calibration point

Error per calibration point

Total RMS error

Export calibration data for analysis

Calibration coefficients

Use Barycentre for pixel value

Add a new calibration point

Complete calibration

Select element filter - A drop down list containing a list of elements contained in the calibration data file. The data is read from the LandaData.dat file in the \Reference sub-folder of the installation folder.

Element Sort - A drop down list next to the element filter that changes the sort order of the element filter drop down.

Browse Calibration File - A button to select which calibration data file to use. The default file CalibLines.dat (in the \Reference folder under the installation path), contains lines most commonly used for calibration, (Hydrogen, Neon, Argon, H20 & Mercury). A LamdaData,dat file is provided (same path) that includes more elements (e.g. Iron, Silicon, Sodium etc.).

You can create your own calibration data file so long as it is in the comma separated value (CSV) text format shown below.

The column definitions are

Element Name	String to display in filter drop down
Element Symbol	String to display in filter drop down
Wavelength	Numeric wavelength (must be in nanometers)
Intensity	Optional intensity value (only used for scaled element lines – See Labels screen)

Example extract
without intensity column

```
Hydrogen,Hη,383.5384
Hydrogen,Hθ,397.0072
Mercury,Hg,435.833
Mercury,Hg,546.074
Mercury,Hg,576.960
Mercury,Hg,578.966
```

Example extract
Including intensity column

```
Hg,3,521.082,30
Th,1,521.123,50
Sc,1,521.128,45
Rh,1,521.152,16
Yb,1,521.16,85
La,1,521.186,720
```

Do not modify CalibLines.dat or LamdaData,dat files. Edit your own copy instead.

Enter Wavelength - A drop down list that contains the list of element lines. These are filtered to a single element if selected from the element filter. You can select from the list or key in the wavelength.

Note: Calibration data points can be temporarily disabled by making the pixel value negative (by inserting a "–" e.g. "123.45" to "-123.45").

Suggest - This button is only enabled once two or more points have been set. When pressed, the system will try each of the items in element lines drop down list and offer the one having the lowest error as the default selection. This is helpful when calibrating an Argon or Neon calibration/reference profile.

This method is not fool proof.

- It depends on the accuracy of the existing points
- Special care and or additional points are required if the dispersion is non-linear (e.g. a prism spectrum).
- The 'true' element line cannot be suggested unless it is included in the element line drop down list.

Barycentre - For advanced use. A check box to use the barycentre, (centre of mass), to derive the element line position. The result is very sensitive to the start and end selection so it may be beneficial to zoom in and/or increase the chart size.

Barycentre is also an option in the Measurements screen. This allows you to practice without doing a calibration.

Data Grid - Each calibration point is represented by a row in the data grid. The columns are described below.

Column	**Description**
Line	The sequence starting at 1 of the calibration points. Read only
Pixel	The pixel where the line was selected on the chart. Editable
Wavelength	The wavelength (in Angstrom, nm or micron) specified at the pixel. The cell value in the last row is synchronised with the value from the wavelength combo box. Editable Setting a wavelength negative will temporarily disable the row.
Error	The difference between the calculated fit and the entered value. Read only
D (Delete Bin)	Clicking the Bin icon will prompt to delete the calibration point

The Screen can be resized to show more rows if necessary

Calibration fit - This drop down list offers a choice of the degree of polynomial required to calculate the fit. When 2 points are taken the only option will be for a linear fit. The list will offer 1-n items, where n is the number of points, but limited to a maximum of 10. The default choice will be a linear fit. Generally speaking, look for the lowest error values as you change the degree of polynomial.

Hint: Use the up and down arrow keys to change the degree of the polynomial as this allows you to see the error values as the degree changes without having to open and close the combo box.

Calibration Data Export - The data export button generates a tab delimited text file with an *.xls extension and prompts for a filename and path to save. Once saved, the user is prompted to launch file using the application associated with the saved file extension. This has been tested with Excel and OpenOffice.

The calibration data can be used for subsequent analysis using a spreadsheet/workbook. See Appendix A – Calibration Export data file for details of the file content.

Total Error text box - This read only text box shows the total error on the points entered. This is calculated as the square root of the sum of each error.

Total RMS and calibration point errors are in the chosen wavelength unit.

Coefficients - This read only text box shows the coefficients derived from the pixel and wavelength pairs of values. These are always in nm to maintain backwards compatibility when stored in *.info.bas files.

Each coefficient is separated with a comma. The number of coefficients depends on the degree of polynomial used. The first value is the offset.

For example a linear fit will have two terms, a and b, corresponding to the offset and slope $f(x) = a + bx$

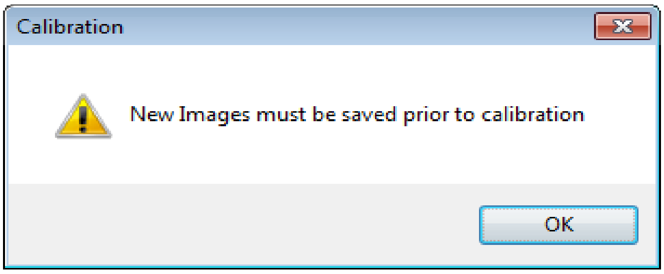
Note: New and/or non-mathematical users need not be intimidated by ‘polynomials’ and ‘coefficients’. These values are fully managed within the application but are made available for advanced users.

2.12.1 New Calibration

The Create/Edit Calibration function (available from the main Calibration menu) is used to calibrate a new image or to modify the calibration on an already calibrated image.

If an existing calibration just needs to be disabled, select the No Calibration option from the Calibration tab of the Profile Properties screen. If calibration data needs to be permanently removed, use the Remove Calibration option under the Calibration menu.

Any new image created, (e.g. by a maths operation, stacking, cropping or resampling etc.), must be saved before it can be calibrated.

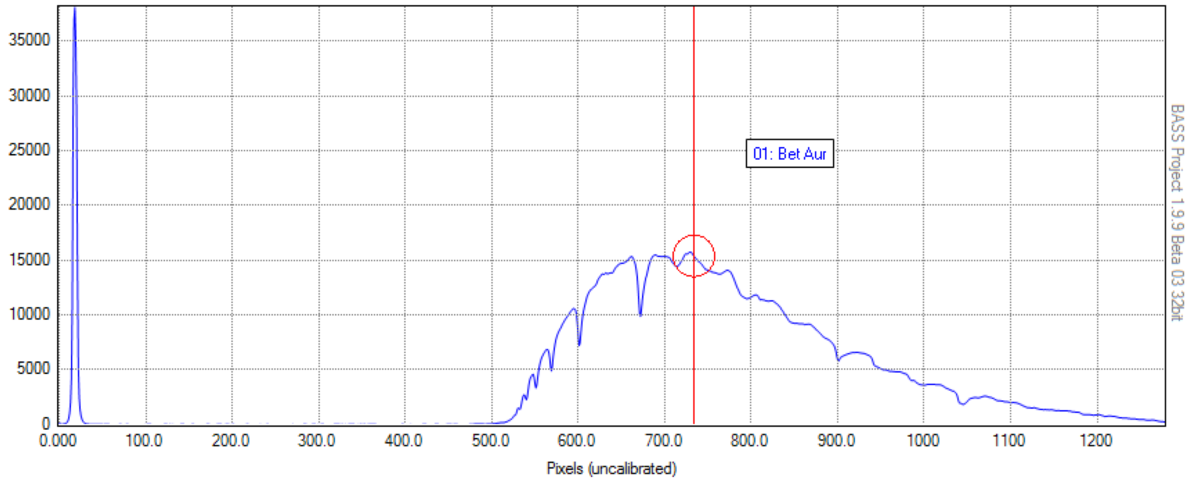


New Images must be saved prior to calibration

2.12.1.1 2 Point calibration

The simplest calibration needs just two reference points and uses a linear best fit line to calculate the wavelength at any pixel position.

Open an uncalibrated spectral image of a star having known absorption lines, then select New Calibration. The cursor and the status bar text will turn red to indicate calibration mode. Notice the red circle that will track the profile as the mouse is moved.



The next step is to identify features and record wavelengths against the features on the chart. There are two ways to identify a feature for calibration purposes

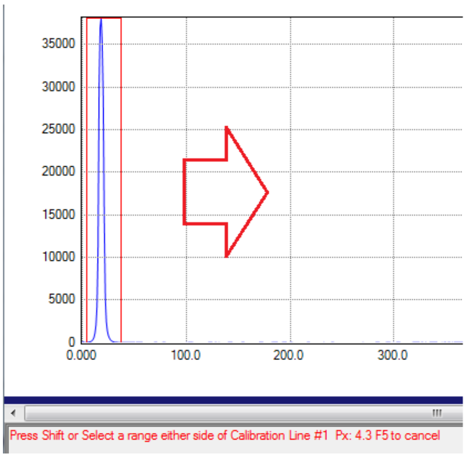
- Select a range of pixels either side of the feature, or
- Double click on the minimum or maximum intensity of a feature.

In the following examples, the zero order peak on the left will be used as the first calibration point.

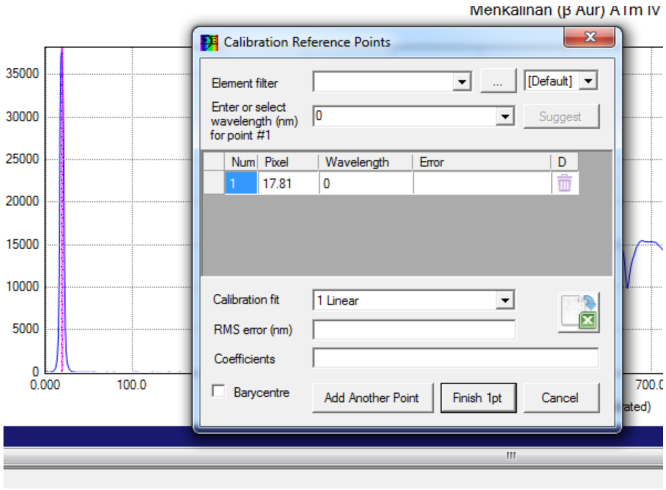
<u>Selecting the calibration point using a range</u>

This is the default option (where the Shift key is NOT held down) and is recommended for most situations. The LH status bar displays a prompt to Press Shift or Select a range either side of the calibration point number (starting from #1)

Click to the left of the first peak and while holding the left mouse button, drag the mouse to the other side of the peak. Releasing the mouse will show the location of the minimum or maximum peak and open the Calibration Reference Line dialog box. This dialog allows you to select from a list of common element lines or manually specify the wavelength. Enter 0 in the wavelength field or select the Zero Order option and press OK.



Press Shift or Select a range either side of Calibration Line #1 Px: 4.3 F5 to cancel



Element filter: [Default]

Enter or select wavelength (nm) for point #1: 0

Num	Pixel	Wavelength	Error
1	17.81	0	

Calibration fit: 1 Linear

RMS error (nm):

Coefficients:

☐ Barycentre

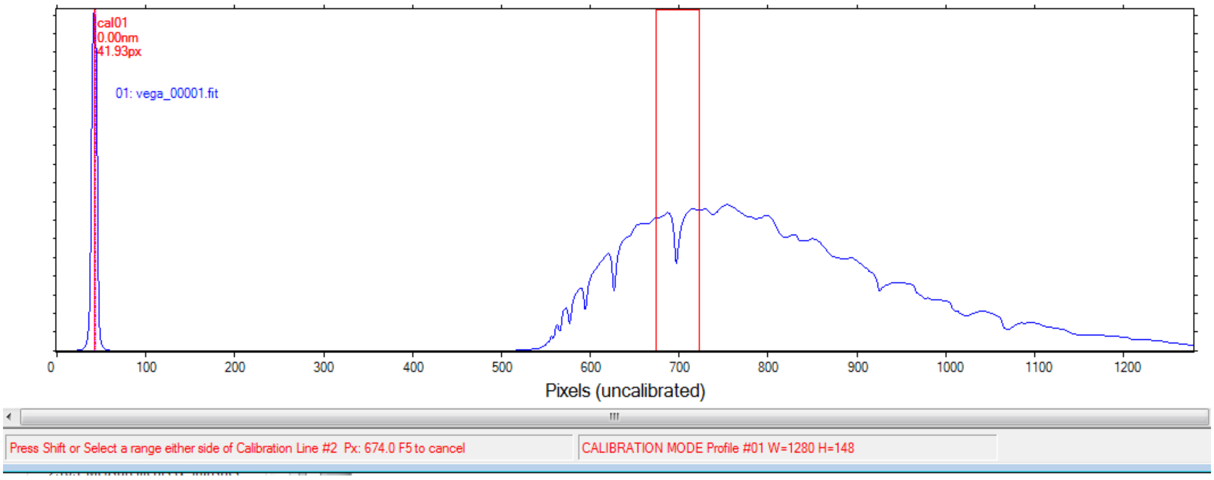
Selecting the calibration point using double click

When the Shift key is held down, the LH status bar displays a prompt to double click and the current calibration point (starting from #1). The cursor pixel position is also displayed.

While holding the Shift key, place the cursor in the centre of the zero order peak and double click. This opens the Calibration Reference Line dialog box allowing you to select from a list of common element lines or manually specify the wavelength. Enter 0 in the wavelength field or select the Zero Order option and press OK.

Adding a second calibration point

Once OK is pressed to accept the first point in the Calibration Reference Line dialog, the status bar will prompt for the Second calibration point. Identify the second reference line to open the Identify Calibration Reference Line dialog.

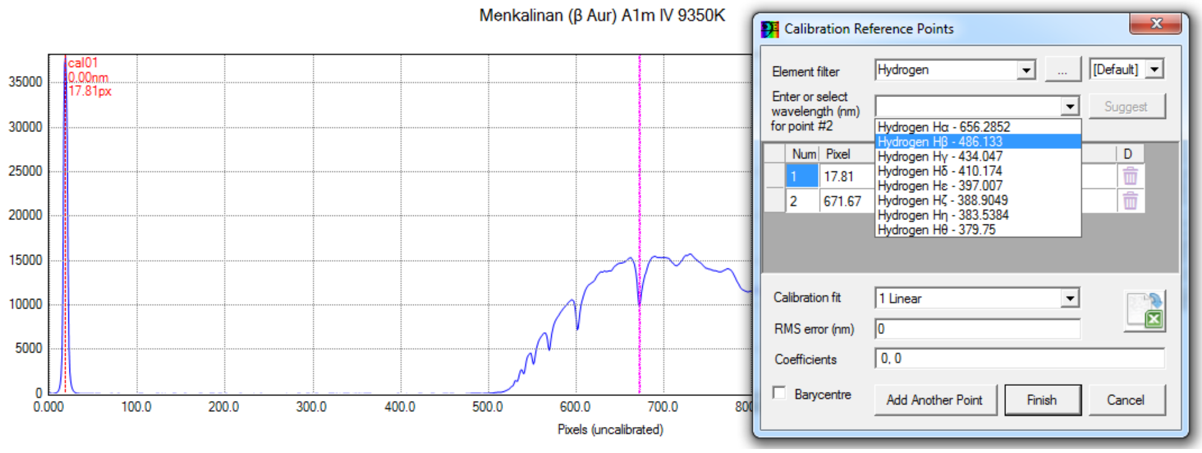


Press Shift or Select a range either side of Calibration Line #2 Px: 674.0 F5 to cancel

CALIBRATION MODE Profile #01 W=1280 H=148

For this example, we select the Hydrogen Beta line as the second reference line. The dialog box can be moved if it obscures the area of interest.

Click on the Select element drop down combo to select the element (Hydrogen in this case) and then select the Hydrogen Beta option from the reference wavelength combo underneath.



Element filter: Hydrogen [Default]

Enter or select wavelength (nm) for point #2:

- Hydrogen Hα - 656.2852
- Hydrogen Hβ - 486.133
- Hydrogen Hγ - 434.047
- Hydrogen Hδ - 410.174
- Hydrogen Hε - 397.007
- Hydrogen Hζ - 388.9049
- Hydrogen Hη - 383.5384
- Hydrogen Hθ - 379.75

Num	Pixel	D
1	17.81	
2	671.67	

Calibration fit: 1 Linear

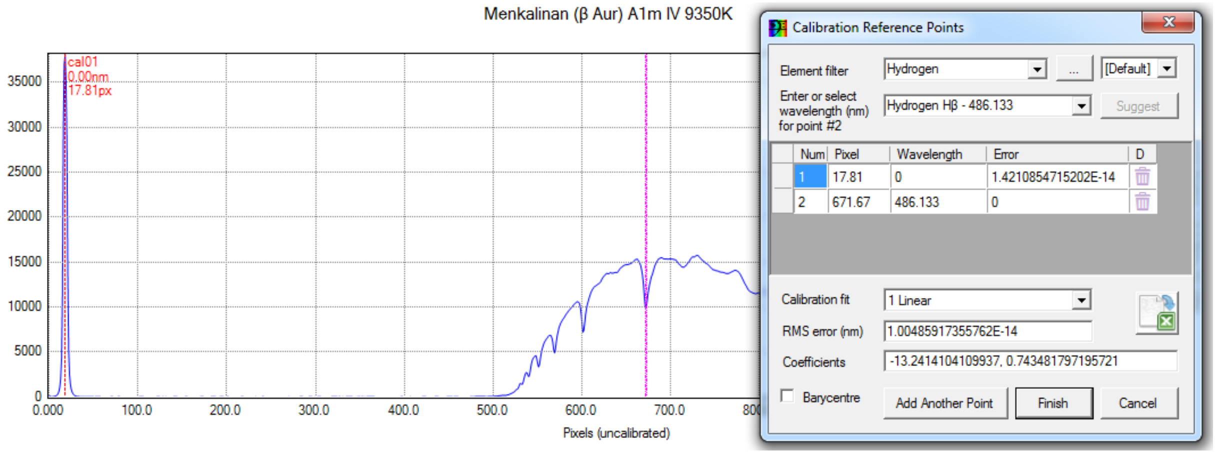
RMS error (nm): 0

Coefficients: 0, 0

☐ Barycentre

Press “Finish” to complete the two point calibration. The chart X-axis now displays wavelength. The status bar (bottom left) will shows the current wavelength when the cursor is moved across the chart.

The calibration lines are visible after a calibration is completed. Use the Show Calibration item under the main Calibration menu to toggle the lines on/off.



Element filter: Hydrogen [Default]

Enter or select wavelength (nm) for point #2: Hydrogen Hβ - 486.133

Num	Pixel	Wavelength	Error	D
1	17.81	0	1.4210854715202E-14	
2	671.67	486.133	0	

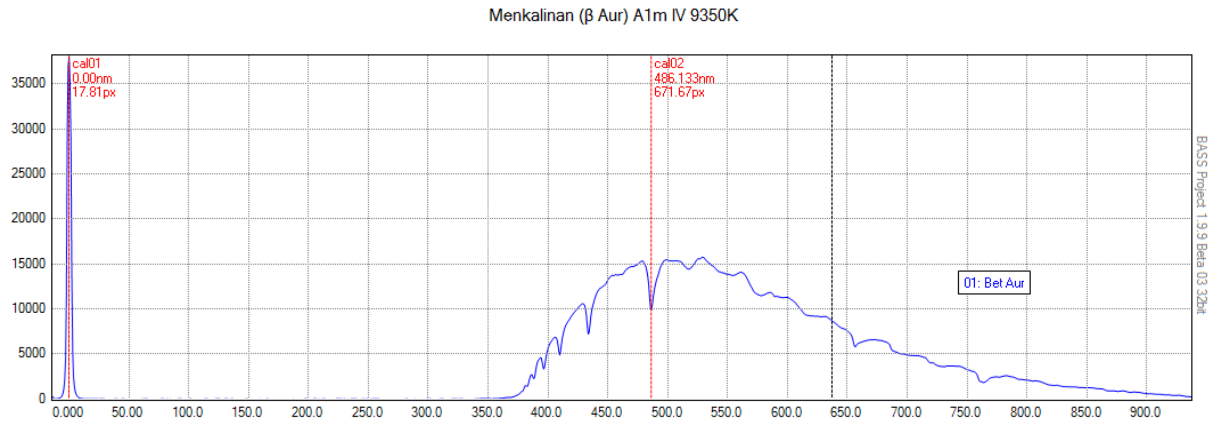
Calibration fit: 1 Linear

RMS error (nm): 1.00485917355762E-14

Coefficients: -13.2414104109937, 0.743481797195721

☐ Barycentre

Press “Finish” to complete the 2 point calibration. The chart X-axis now displays wavelength. The status bar (bottom left) will shows the current wavelength when the cursor is moved across the chart.



The calibration lines are visible after a calibration is completed. Use the Show Calibration item under the main Calibration menu to toggle the lines on/off.

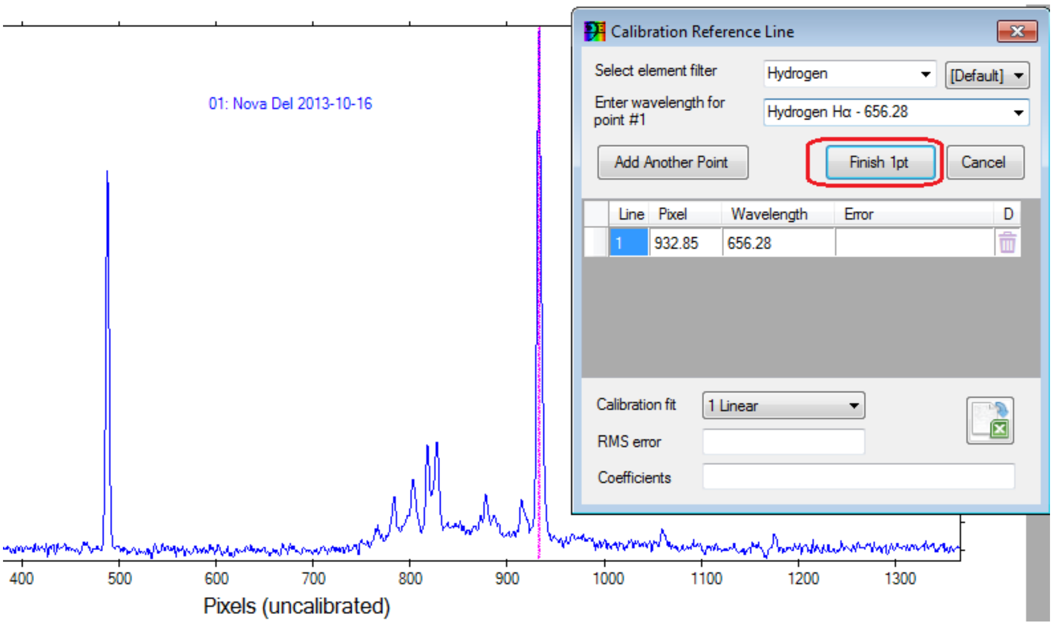
Note: Increasing the working size of the chart prior to calibration can allow a more accurate setting of calibration points when using the Double Click method. Chart size is set via the Edit Project Chart settings option under the main Chart menu.

Note: The calibration points and the calibration equation coefficients are saved into the profile's ".info.bas" image information file. The calibration equation 'coefficients' are visible in the Calibration tab of the Profile Properties screen.

2.12.1.2 Single-point calibration

A single point calibration can be used when the linear dispersion is already accurately known.

First calibrate a feature on the chart where the wavelength is known, (Hydrogen Alpha in the example below).



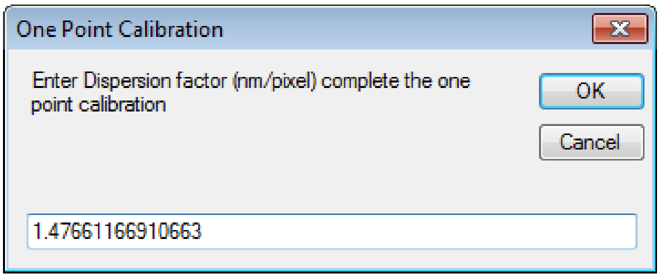
Select element filter: Hydrogen [Default]

Enter wavelength for point #1: Hydrogen Hα - 656.28

Line	Pixel	Wavelength	Error	D
1	932.85	656.28		

Calibration fit: 1 Linear

Next press the ‘Finish 1Pt’ button and key in the dispersion factor (in your chosen wavelength unit per pixel) into the pop-up box provided.



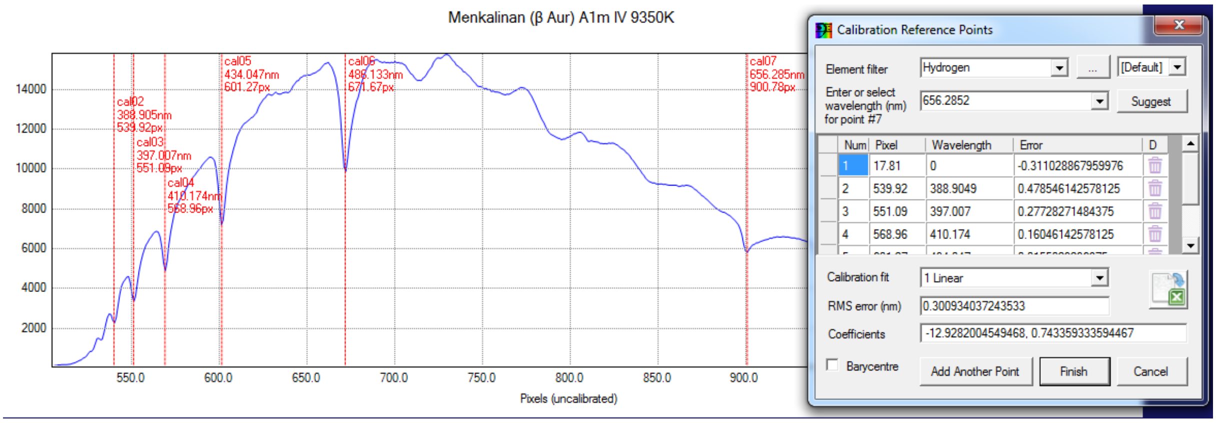
Enter Dispersion factor (nm/pixel) complete the one point calibration

1.47661166910663

2.12.1.3 Multiple-point calibration

A multiple point calibration uses three or more points to calculate a polynomial best fit curve that is used to translate pixel position to wavelength. The reader should be familiar with the techniques used in a 2-point calibration before proceeding.

The process is similar to the 2-point calibration except that the “Add Another Point” button is clicked when the second point is being set. The ‘Add Another’ button accepts the second wavelength and prompts you to identify the third wavelength. You can repeat the process to keep on adding more calibration points until the “Finish” button is clicked.



Element filter: Hydrogen; [Default]

Enter or select wavelength (nm) for point #7: 656.2852

Num	Pixel	Wavelength	Error	D
1	17.81	0	-0.311028867959976	
2	539.92	388.9049	0.478546142578125	
3	551.09	397.007	0.27728271484375	
4	568.96	410.174	0.16046142578125	

Calibration fit: 1 Linear

RMS error (nm): 0.300934037243533

Coefficients: -12.9282004549468, 0.743359333594467

2.12.2 Edit Calibration

An existing calibration can be edited for calibration points to be added (or removed) and/or the degree of polynomial regression to be changed.

With a calibrated profile loaded, select the Create/Edit Calibration item from the main calibration menu. This opens the ‘Calibration Reference Line’ dialog in the state that it was previously in, just before the calibration was completed.

The options available are:

- Edit the wavelength of the last calibration point
- Press Add Another Point to add more calibration points

- Delete one or more rows from the grid
- Edit values in pixel or wavelength columns (double click or press F2)
- Change the Calibration fit (degree of polynomial)
- Export calibration data for analysis

When a calibration edit is in progress the existing calibration and instrument response are disabled so the profile returns to its raw state. This will revert back if the calibration is cancelled.

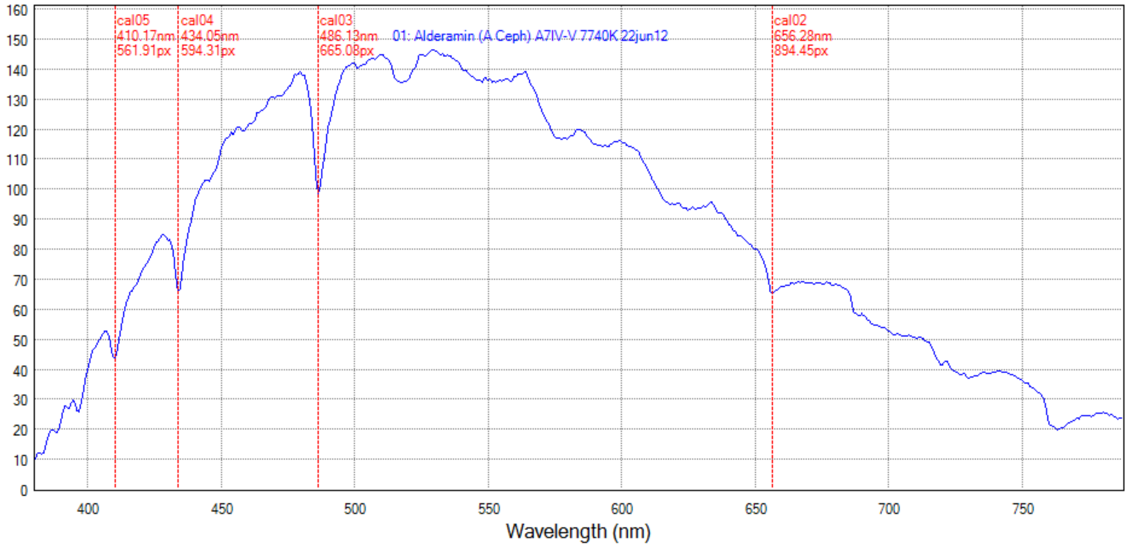
2.12.3 Remove Calibration

This menu option will prompt for calibration data, (data points and polynomial coefficients), to be removed from the selected profile. Calibration data in the *.info.bas file will also be blanked.

Note: This only removes calibration from profiles calibrated within this application. This will not affect DAT files where wavelength is already stored as the first field within a profile. It will also not remove any calibration held within a FITS header (these can be blanked out using the BeSS Settings screen

2.12.4 Show/Hide Calibration Points

The menu option will toggle the display of calibration points (of the top profile).



Each calibration label shows the following

- 'cal' + sequence number that the point was added
- Wavelength (in Angstrom, nm or micron as setup in Chart Settings)
- Pixel Position

Calibration lines and labels are always shown in red.

2.12.5 Use Minimal Calibration Text

The menu option will provide an alternative minimal view of the calibration points just showing the wavelength. In addition, this option staggers the position of the labels to avoid overlaps when lines are congested.

2.12.6 Using Reference lamps

A reference lamp can be used to provide the reference wavelengths for calibration.

- The reference lamp spectrum should be positioned at the top image strip (sequence number 01) in the project with target image(s) loaded beneath.
- Apply tilt, smile and/or slant corrections as required, but ensure the “Apply to all” option is ticked so that the reference and target images get the same correction applied.
- Calibrate the reference image using the known lines.
- Copy the calibration from the reference to the target spectra.

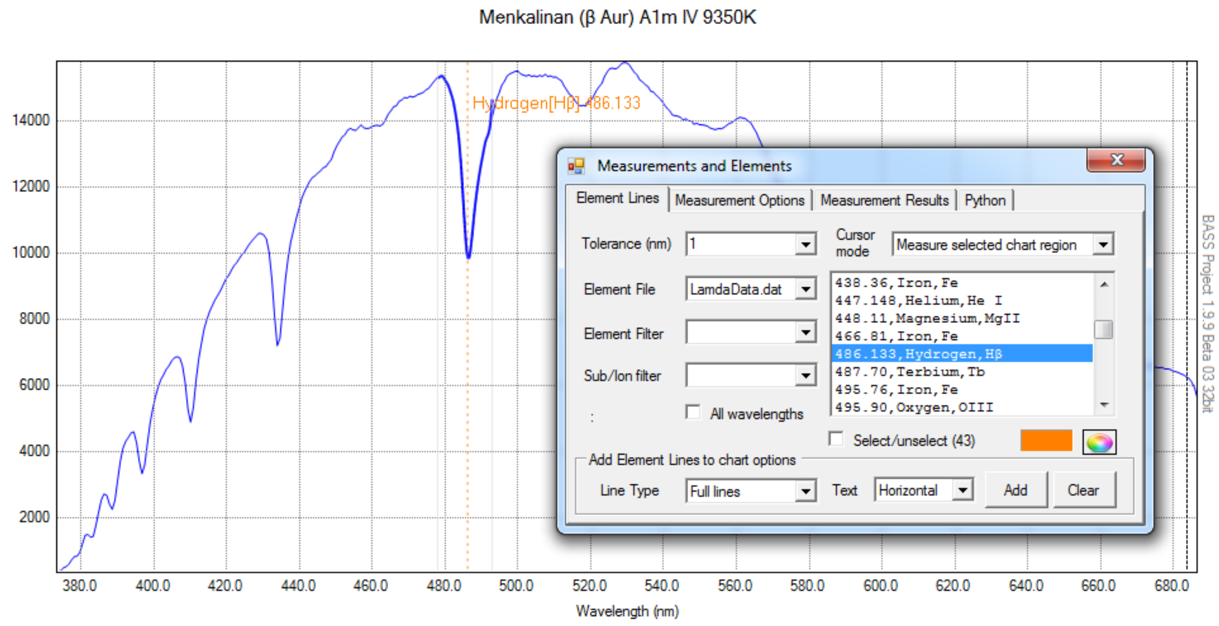
2.13 Measurements & Elements screen

The Measurements & Elements screen, (accessed via the toolbar icon or main Tools menu), can be used display measurements and statistics based on a range selected on the active profile. This screen also allows lines from elements to be added to the chart.

The screen is divided up into four tab header sections

- Elements Lines
- Measurement Options
- Measurement Results
- Python

To take a ‘measurement’, select a range on the chart (after the Measurements & Elements screen is opened). The selected range is shown using a bold/thicker line.



Tolerance (nm) 1

Cursor mode Measure selected chart region

Element File LamdaData.dat

Element Filter

Sub/Ion filter

☐ All wavelengths

```
438.36,Iron,Fe
447.148,Helium,He I
448.11,Magnesium,MgII
466.81,Iron,Fe
486.133,Hydrogen,Hβ
487.70,Terbium,Tb
495.76,Iron,Fe
495.90,Oxygen,OIII
```

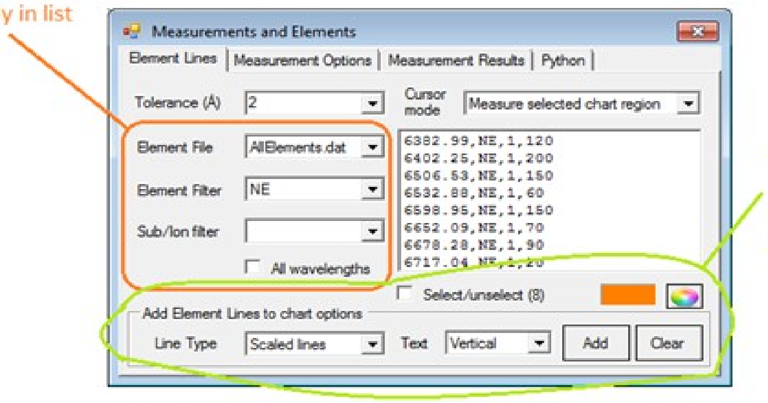
☐ Select/unselect (43)

Line Type Full lines

Text Horizontal

2.13.1 Element Lines tab

Filter lines to display in list



Tolerance (Å) 2

Cursor mode Measure selected chart region

Element File AllElements.dat

Element Filter NE

Sub/Ion filter

☐ All wavelengths

```
6382.99,NE,1,120
6402.25,NE,1,200
6506.53,NE,1,150
6532.88,NE,1,60
6598.95,NE,1,150
6652.09,NE,1,70
6678.28,NE,1,90
6717.04,NE,1,20
```

☐ Select/unselect (8)

Line Type Scaled lines

Text Vertical

Set properties for labels added to chart & Labels screen

The Element Lines tab is displayed by default when the screen is invoked with a calibrated chart. This functionality is not available unless the chart is calibrated.

When a measurement is taken, the application will search within the min or max wavelength against a list of element lines. The closest match, within a specified tolerance, is highlighted in the list box[1]. If one of the 'Line Type' options is selected, and the Shift key is held while the mouse makes a selection, then a line is automatically added to the chart.

[1]It is important to understand that the tool to search and identify a single element line is just indicative. It extremely sensitive to calibration errors so should be used with caution.

While results can be useful with a small data source file restricted to the main Solar lines, it can be misleading when used with a large data source because there can *be hundreds of possible element matches even within a small tolerance.*

Data Source - The default data source for the element lines is currently maintained in the small text file, LamdaData.dat, found in the \Reference folder under the installation path (the same file can be used for calibration). This file contains only the common element lines (based mainly on the Solar Fraunhofer lines)

Alternative data source files can be used so long as they are placed in the same location and are in the same comma separated format with the following fields

- Element Name
- Element Symbol
- Wavelength (in Angstrom, nm or micron)
- (Optional) Intensity[2]

[2] Elements data files having an additional ‘intensity’ column populated are also supported. This intensity value is used to scale reference lines relative to one another, per element.

Element Lines - The Elements Lines list box shows the element lines from the data source and element filter selections.

Element Filter - The element filter drop down list offers a selection of elements that are contained in the data source file. [none] will search across all elements in the file.

The filter selection will update the element lines in the element lines list box.

Tolerance - The Tolerance drop down list determines how precise the match needs to be. This will depend on many factors including the spectrometer configuration. Use higher values for low resolution spectra, e.g. try 1 or 2 nm (100 to 200A) with a Star Analyser 100.

Colour - The Colour picker allows choice of the colour for element lines subsequently added.

Element display actions

The Element display options drop down list performs two functions:

- Determines if and how a matching element will be displayed on the chart after a measurement
- Allows the user to manually add element lines (independently of the measurement).

The Add lines drop down list provides three options

- Show element lines only – a dotted line without text is displayed
- Show element lines + text – a dotted line plus element symbol and wavelength are displayed.
- Add to Labels Screen – adds the line in a format where it can be managed using the Labels screen

Add - This button will add element lines to the chart as specified in the drop down list.

Clear - The Clear button will remove labels of the same type specified by Line Type

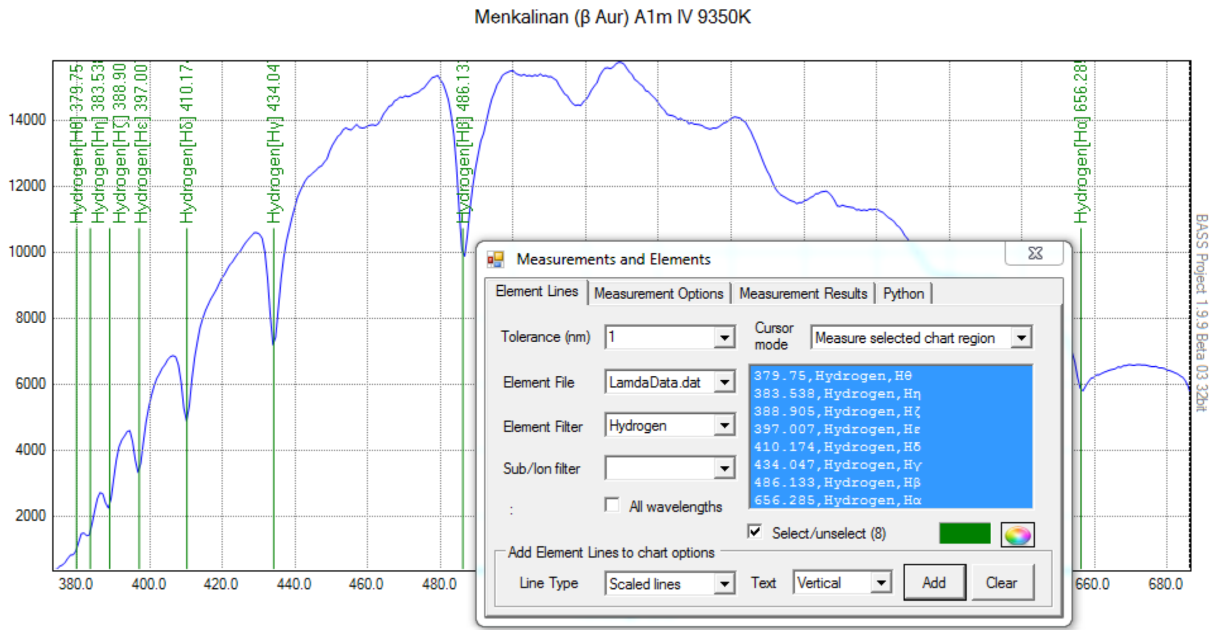
2.13.2 Manually adding element lines

This allows known spectral lines of elements to be superimposed onto a chart (typically in order to see if they correspond with unknown lines from your spectrum).

This is best illustrated with a simple example to display the Hydrogen Balmer lines.

With the Measurements & Elements screen displayed:

- Select LamdaData.Dat as the data source
- Select Hydrogen from the Element Filter drop down list
- Click the Select/unselect checkbox to select all lines (or select individual items).
- Select Scaled lines from the Line Type drop down list.
- Select Vertical from the Text drop down list
- Press Add button



Tolerance (nm): 1

Cursor mode: Measure selected chart region

Element File: LamdaData.dat

Element Filter: Hydrogen

Sub/Ion filter:

☐ All wavelengths

```
379.75,Hydrogen,Hθ
383.538,Hydrogen,Hη
388.905,Hydrogen,Hζ
397.007,Hydrogen,Hε
410.174,Hydrogen,Hδ
434.047,Hydrogen,Hγ
486.133,Hydrogen,Hβ
656.285,Hydrogen,Hα
```

☑ Select/unselect (8)

Add Element Lines to chart options

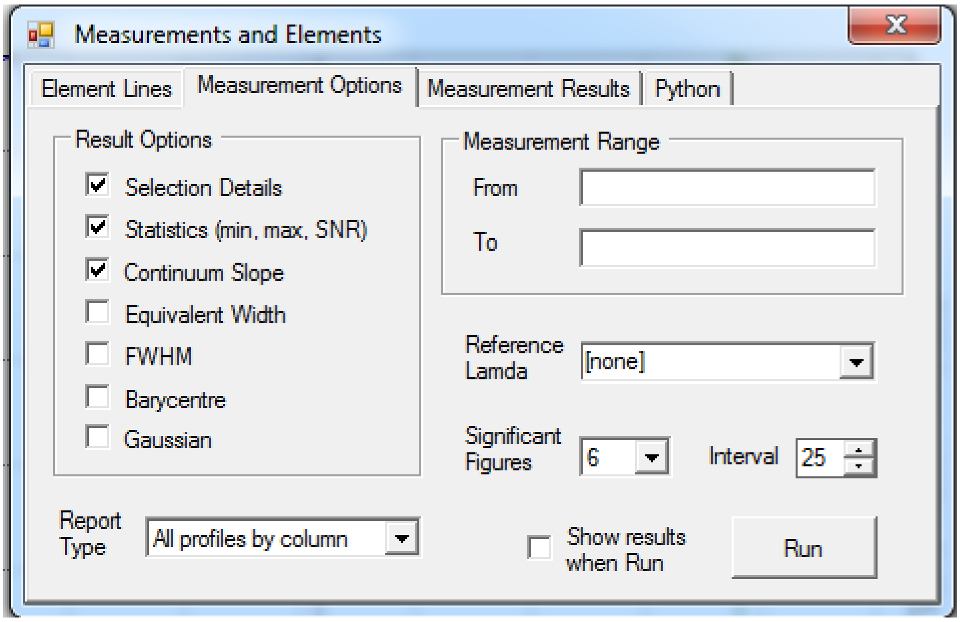
Line Type: Scaled lines

Text: Vertical

Note The lines added can be individually modified from the the Labels screen 2.26.2.

2.13.3 Measurements Options

This tab determines which measurements & statistics will be displayed in the Measurement Results tab when a measurement is taken. The unit for all intensity measurements will be ADU.



☑ Selection Details
☑ Statistics (min, max, SNR)
☑ Continuum Slope
☐ Equivalent Width
☐ FWHM
☐ Barycentre
☐ Gaussian

From
To

Reference Lamda: [none]
Significant Figures: 6
Interval: 25
Report Type: All profiles by column
☐ Show results when Run

There are two ways to take a measurement:

- Select a region on the chart using the mouse (click and hold left mouse button to start, drag to the end and then release).
- Key in ‘From’ and ‘To’ measurement range and press the Run button

Result Options – This panel provides check boxes to choose what data will be returned

- Selection Details
  - Selected start, end & width in pixels, wavelength if calibrated and velocity if the X-axis is in Doppler Shift mode.
- Statistics (min, max, SNR)
  - Max and Min Flux - and the corresponding pixels, (wavelengths if calibrated and velocities if the X-axis is in Doppler Shift mode)
  - Flux Range (Max – Min intensity)
  - Average Flux –RMS Intensity (as root mean square of the 1-dimensional profile intensity)
  - Average and root mean square (RMS) flux values
  - Standard Deviation
  - Signal to Noise Ratio (SNR) as Average Flux / Standard Deviation

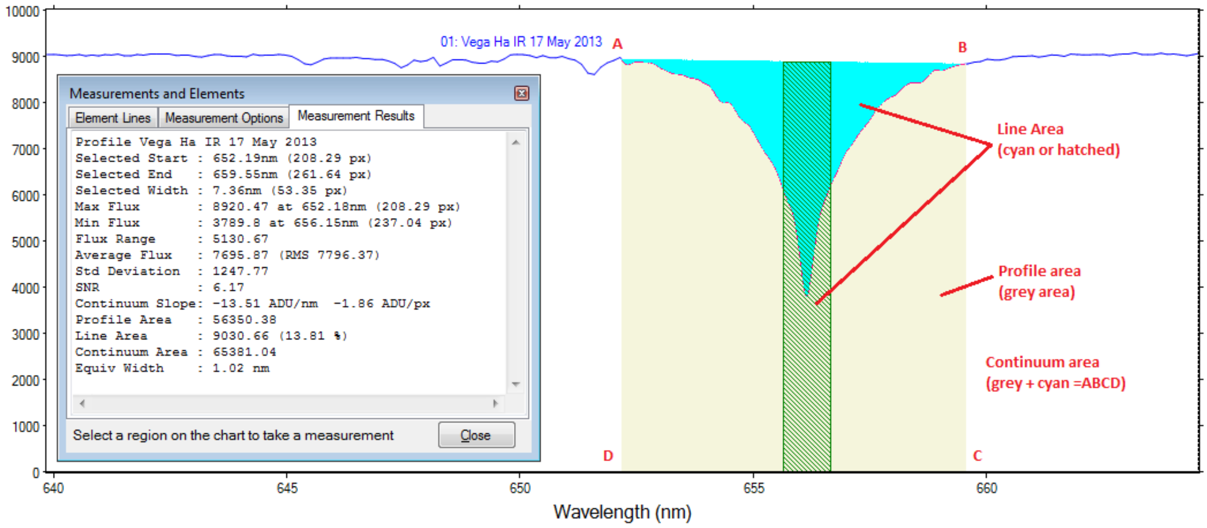
Note: Doppler Shift mode is enabled via the X-axis tab of the Chart Settings screen.

- Continuum Slope
  - Slope of the intensity continuum from selection start to end. Displays ADU per wavelength unit (where calibrated) and ADU/pixel
- Equivalent Width
  - Profile Area (area under line)

- Line Area (area excluding continuum). Also shown as percent of profile area
- Continuum Area. The area of line between start and end points and zero flux
- Equivalent Width (EW)

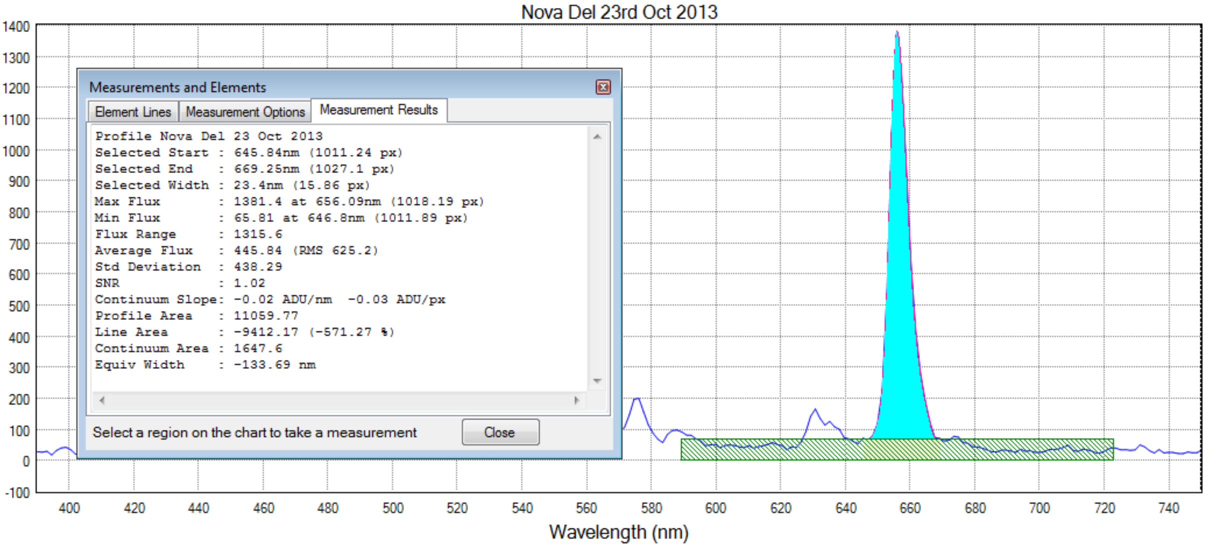
EW is a measure of the area of the line on a plot of intensity versus wavelength and provides an indication of the power of the line.

The EW area is shown as a hatched rectangle and is not indicative unless the chart y-axis starts at zero or less and the rectangle fits within the x-axis bounds.



```
Profile Vega Ha IR 17 May 2013
Selected Start : 652.19nm (208.29 px)
Selected End   : 659.55nm (261.64 px)
Selected Width : 7.36nm (53.35 px)
Max Flux       : 8920.47 at 652.18nm (208.29 px)
Min Flux       : 3789.8 at 656.15nm (237.04 px)
Flux Range     : 5130.67
Average Flux   : 7695.87 (RMS 7796.37)
Std Deviation  : 1247.77
SNR            : 6.17
Continuum Slope: -13.51 ADU/nm  -1.86 ADU/px
Profile Area   : 56350.38
Line Area      : 9030.66 (13.81 %)
Continuum Area : 65381.04
Equiv Width    : 1.02 nm
```

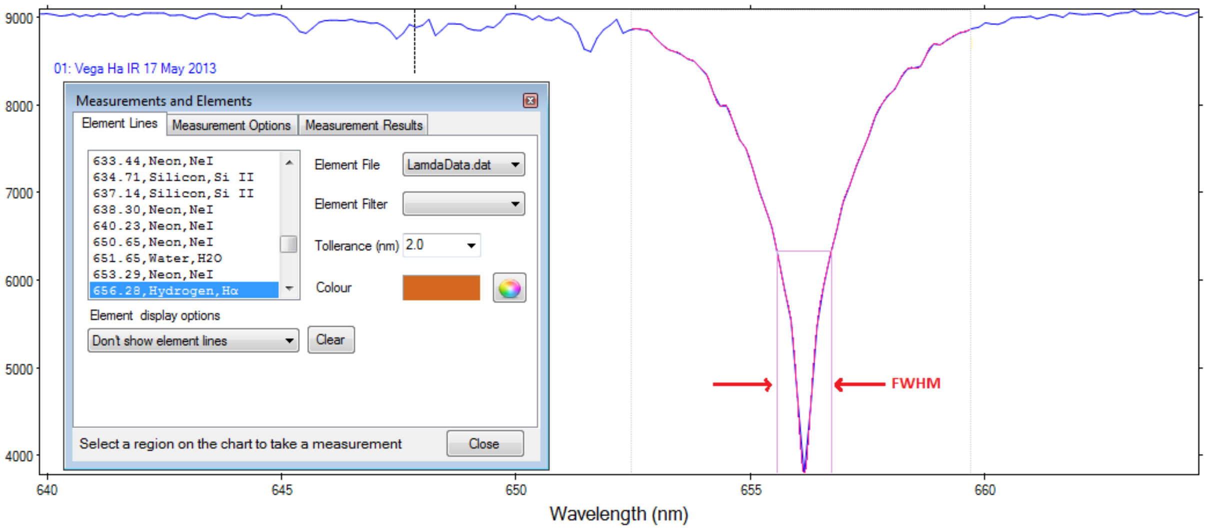
For emission lines, the EW will be negative.



```
Profile Nova Del 23 Oct 2013
Selected Start : 645.84nm (1011.24 px)
Selected End   : 669.25nm (1027.1 px)
Selected Width : 23.4nm (15.86 px)
Max Flux       : 1381.4 at 656.09nm (1018.19 px)
Min Flux       : 65.81 at 646.8nm (1011.89 px)
Flux Range     : 1315.6
Average Flux   : 445.84 (RMS 625.2)
Std Deviation  : 438.29
SNR            : 1.02
Continuum Slope: -0.02 ADU/nm  -0.03 ADU/px
Profile Area   : 11059.77
Line Area      : -9412.17 (-571.27 %)
Continuum Area : 1647.6
Equiv Width    : -133.69 nm
```

- FWHM

- Full width half maximum in chosen wavelength unit (or pixels if not calibrated). This uses a graphical calculation method (to distinguish from a Gaussian fit method).
- If calibrated, the calculated R (resolving power = Wavelength / FWHM) is also displayed.
  Note the R value assumes the measured line is from a reference lamp or similar. Since this value is mostly used for indicative purposes, it will be rounded to the nearest whole value.



```
633.44,Neon,NeI
634.71,Silicon,Si II
637.14,Silicon,Si II
638.30,Neon,NeI
640.23,Neon,NeI
650.65,Neon,NeI
651.65,Water,H2O
653.29,Neon,NeI
656.28,Hydrogen,Hα
```

Element File: LamdaData.dat

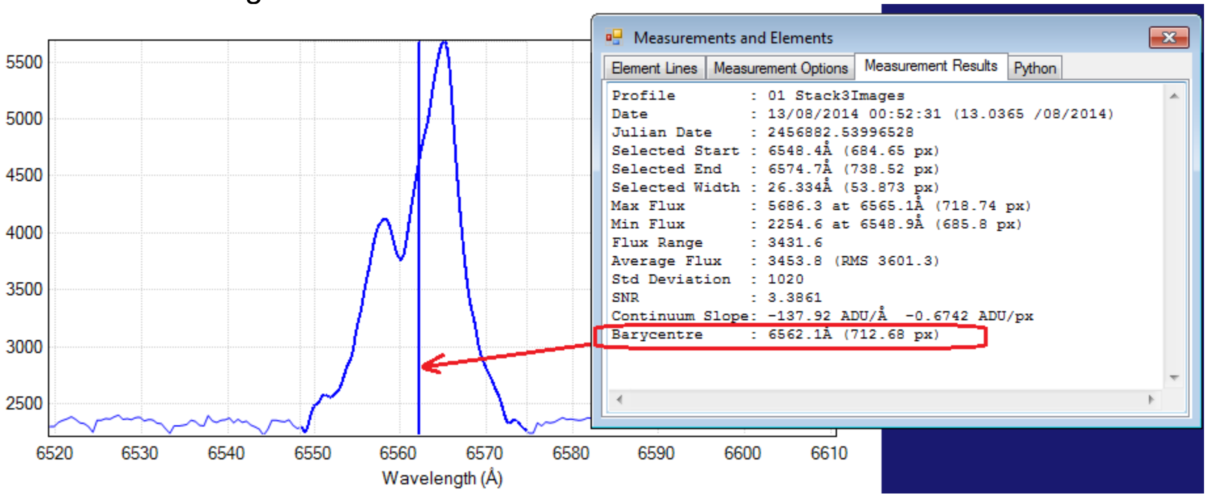
Tollerance (nm): 2.0

Element display options: Don't show element lines

Select a region on the chart to take a measurement

- Barycentre

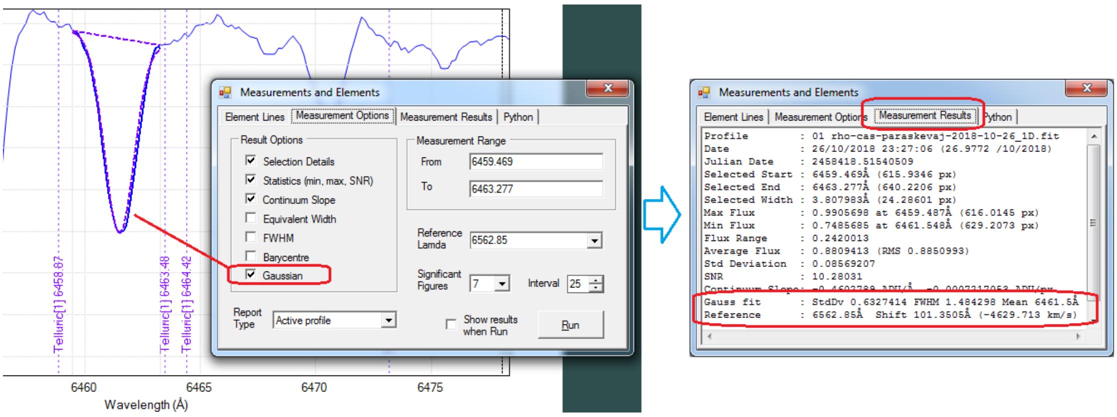
  This displays a vertical line to show the barycentre (centre of mass) of the selected region



```
Profile        : 01 Stack3Images
Date           : 13/08/2014 00:52:31 (13.0365 /08/2014)
Julian Date    : 2456882.53996528
Selected Start : 6548.4Å (684.65 px)
Selected End   : 6574.7Å (738.52 px)
Selected Width : 26.334Å (53.873 px)
Max Flux       : 5686.3 at 6565.1Å (718.74 px)
Min Flux       : 2254.6 at 6548.9Å (685.8 px)
Flux Range     : 3431.6
Average Flux   : 3453.8 (RMS 3601.3)
Std Deviation  : 1020
SNR            : 3.3861
Continuum Slope: -137.92 ADU/Å  -0.6742 ADU/px
Barycentre     : 6562.1Å (712.68 px)
```

- Gaussian

  This checkbox will draw a Gaussian curve within the start and end selection range and include standard deviation, FWHM and mean in the results. Fitting the curve is a manual process. Experiment with the selection to get the best fit.



Result Options
☑ Selection Details
☑ Statistics (min, max, SNR)
☑ Continuum Slope
☐ Equivalent Width
☐ FWHM
☐ Barycentre
☑ Gaussian

Measurement Range
From 6459.469
To 6463.277

Reference Lamda 6562.85
Significant Figures 7
Interval 25
Report Type Active profile
☐ Show results when Run

```
Profile         : 01 rho-cas-paraskevaj-2018-10-26_1D.fit
Date            : 26/10/2018 23:27:06 (26.9772 /10/2018)
Julian Date     : 2458418.51540509
Selected Start  : 6459.469Å (615.9346 px)
Selected End    : 6463.277Å (640.2206 px)
Selected Width  : 3.807983Å (24.28601 px)
Max Flux        : 0.9905698 at 6459.487Å (616.0145 px)
Min Flux        : 0.7485685 at 6461.548Å (629.2073 px)
Flux Range      : 0.2420013
Average Flux    : 0.8809413 (RMS 0.8850993)
Std Deviation   : 0.08569207
SNR             : 10.28031
Continuum Slope: -0.4603789 ADU/Å  -0.0007317053 ADU/px
Gauss fit       : StdDv 0.6327414 FWHM 1.484298 Mean 6461.5Å
Reference       : 6562.85Å  Shift 101.3505Å (-4629.713 km/s)
```

Report Type – Drop down list determines the output format of the results and also if only the active profile, or all the profiles, will be simultaneously measured. The options are described in the Measurement Results tab.

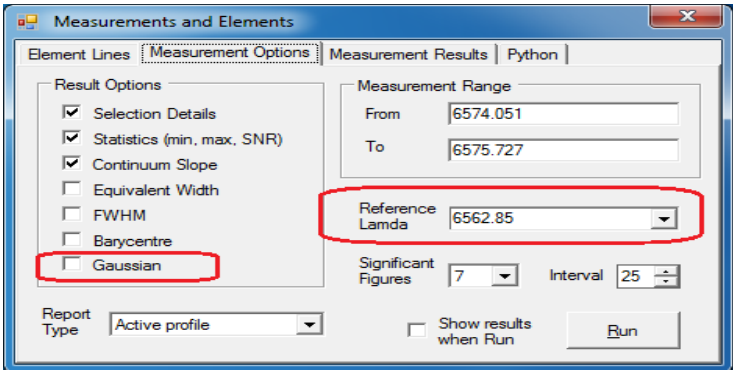
Measurement Range - The 'from' and 'to' text boxes are populated when a measurement is taken using a mouse selection. Values can also me keyed in to allow repeatable measurements.

Units are in Angstrom, nm or micron, (or pixel if chart is not calibrated)

Reference Lamda - This drop down list supports measurement of wavelength relative to a reference wavelength. It shows the difference in wavelength and Doppler velocity. This can save a lot of time and effort when a large number of RV measurements are required.

The Reference Lamda drop down list allows the following options

- [none] – no differences will be calculated.
- [auto] – the Reference wavelength will be automatically chosen if it exists in the selected range. (When more than one line exists in the selection, the first reference line from left is used).
- Select a specific wavelength from the drop down list (that is populated with values as per list box in the Element Lines tab).
- You can also manually key in a wavelength value that is not in the list. e.g. 6562.85.



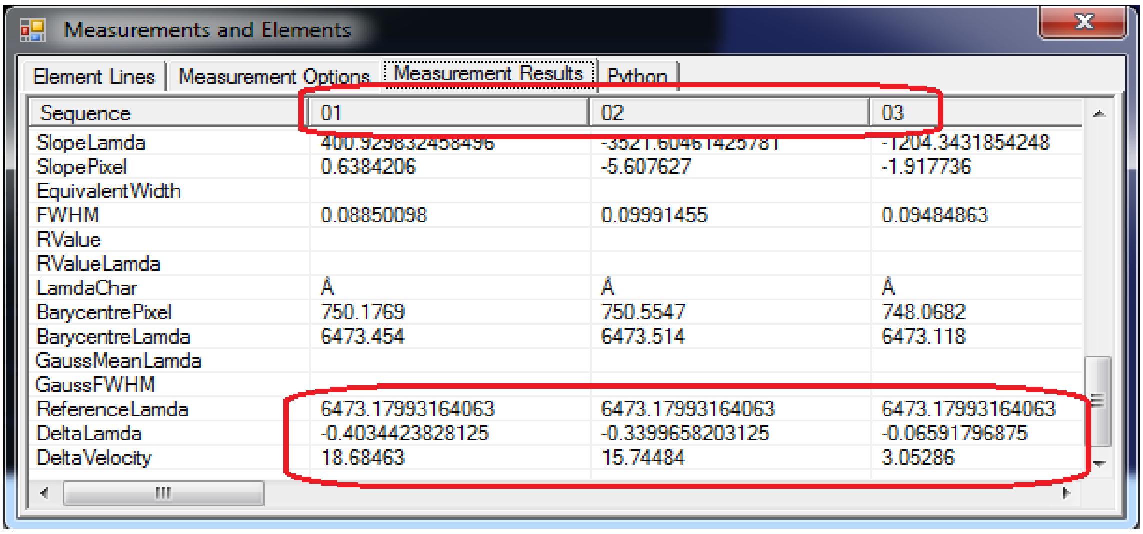
Result Options
☑ Selection Details
☑ Statistics (min, max, SNR)
☑ Continuum Slope
☐ Equivalent Width
☐ FWHM
☐ Barycentre
☐ Gaussian

Measurement Range
From 6574.051
To 6575.727

Reference Lamda 6562.85
Significant Figures 7
Interval 25
Report Type Active profile
☐ Show results when Run

The measured value uses a Cubic Spline interpolation based on the maximum (for emission) or minimum (for absorption) value within the selection. The average of a Gaussian fit will be used instead if the Gaussian checkbox is ticked.

When used in combination with the Report Type (in Report Options tab) = 'All Profiles by Column' or 'All Profiles by Row', then RV measurements relative to a single reference can be calculated for a set of profiles.



Sequence	01	02	03
SlopeLamda	400.929832458496	-3521.60461425781	-1204.3431854248
SlopePixel	0.6384206	-5.607627	-1.917736
EquivalentWidth			
FWHM	0.08850098	0.09991455	0.09484863
RValue			
RValueLamda			
LamdaChar	Å	Å	Å
BarycentrePixel	750.1769	750.5547	748.0682
BarycentreLamda	6473.454	6473.514	6473.118
GaussMeanLamda			
GaussFWHM			
ReferenceLamda	6473.17993164063	6473.17993164063	6473.17993164063
DeltaLamda	-0.4034423828125	-0.3399658203125	-0.06591796875
DeltaVelocity	18.68463	15.74484	3.05286

Sig. Figures – A drop down list to specify the number of significant figures for measurement results to be displayed.

Note: Results are formatted after calculations are made using unrounded values

Interval – The number of slices between pixels for interpolation and area calculations. Lower values can speed processing, but with possibly less accuracy. Default = 20

Show Results when run – A checkbox that switches to the Measurement Results tab when Run is clicked.

Run – A button to take a measurement. A measurement is also triggered when a selection has been made using the mouse.

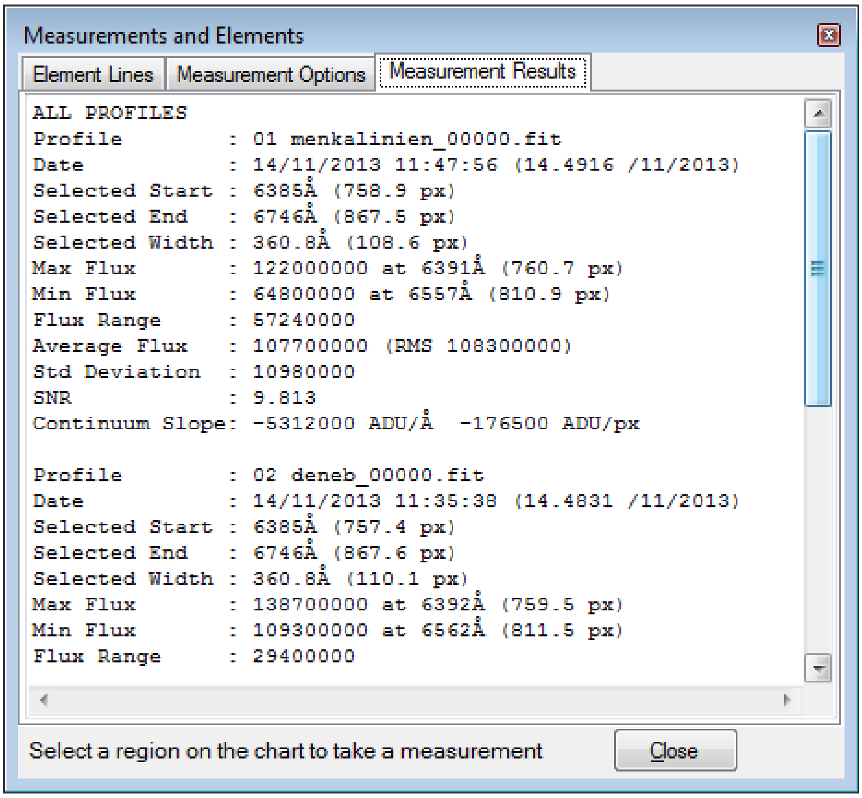
2.13.4 Measurements Results

The Measurement Results tab shows the calculated measurements based on the parameters and options specified in the Measurement Options tab.

The output format is determined by the Report Type drop down list as follows:

- Active Profile – Displays text report of active profile only for selected Result Options

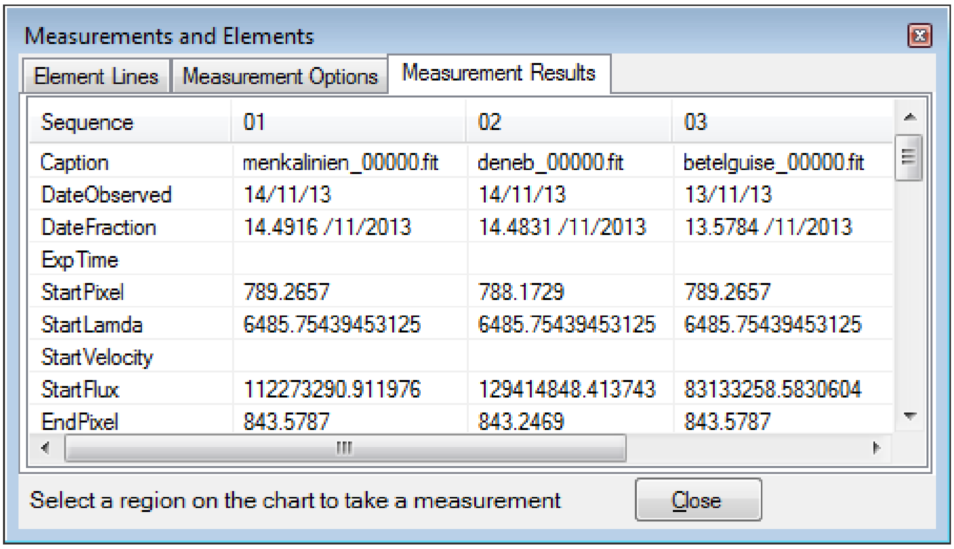
- All Profiles – Displays text report for every profile one above another (scroll down to see other profiles)



```
ALL PROFILES
Profile         : 01 menkalinien_00000.fit
Date            : 14/11/2013 11:47:56 (14.4916 /11/2013)
Selected Start  : 6385Å (758.9 px)
Selected End    : 6746Å (867.5 px)
Selected Width  : 360.8Å (108.6 px)
Max Flux        : 122000000 at 6391Å (760.7 px)
Min Flux        : 64800000 at 6557Å (810.9 px)
Flux Range      : 57240000
Average Flux    : 107700000 (RMS 108300000)
Std Deviation   : 10980000
SNR             : 9.813
Continuum Slope: -5312000 ADU/Å  -176500 ADU/px

Profile         : 02 deneb_00000.fit
Date            : 14/11/2013 11:35:38 (14.4831 /11/2013)
Selected Start  : 6385Å (757.4 px)
Selected End    : 6746Å (867.6 px)
Selected Width  : 360.8Å (110.1 px)
Max Flux        : 138700000 at 6392Å (759.5 px)
Min Flux        : 109300000 at 6562Å (811.5 px)
Flux Range      : 29400000
```

Select a region on the chart to take a measurement

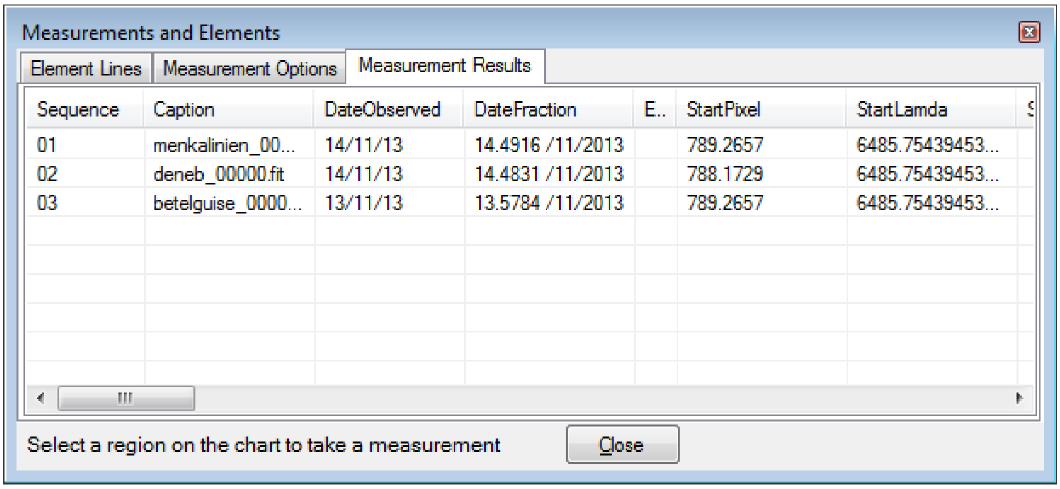
- All Profiles by Column – Displays a data grid with a column per profile



Sequence	01	02	03
Caption	menkalinien_00000.fit	deneb_00000.fit	betelguise_00000.fit
DateObserved	14/11/13	14/11/13	13/11/13
DateFraction	14.4916 /11/2013	14.4831 /11/2013	13.5784 /11/2013
ExpTime			
StartPixel	789.2657	788.1729	789.2657
StartLamda	6485.75439453125	6485.75439453125	6485.75439453125
StartVelocity			
StartFlux	112273290.911976	129414848.413743	83133258.5830604
EndPixel	843.5787	843.2469	843.5787

Select a region on the chart to take a measurement

- All Profiles by Row – Displays a data grid with a row per profile.



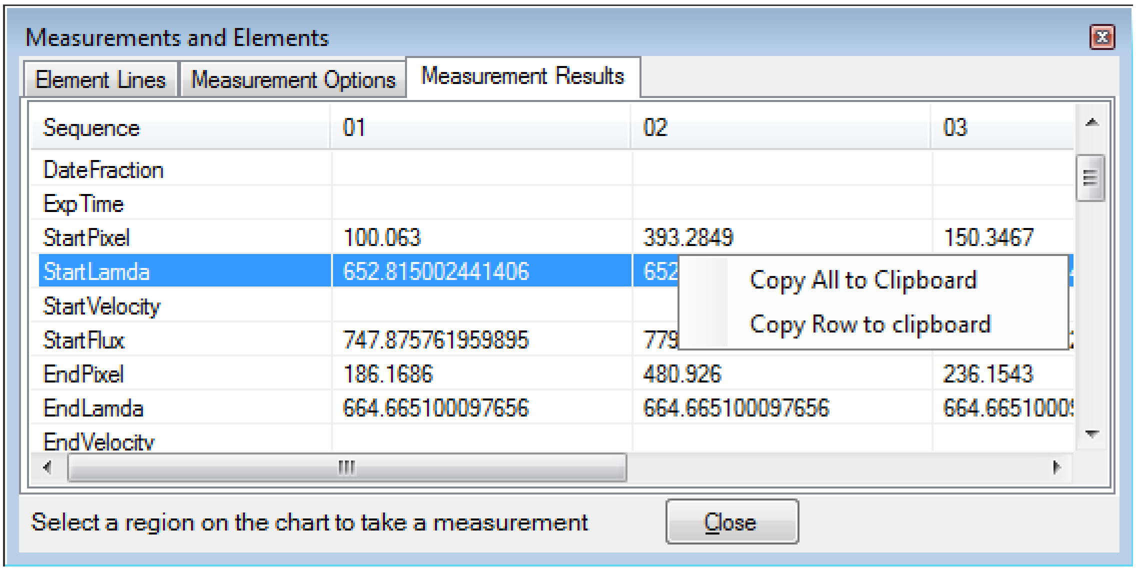
Sequence	Caption	DateObserved	DateFraction	E..	StartPixel	StartLamda
01	menkalinien_00...	14/11/13	14.4916 /11/2013		789.2657	6485.75439453...
02	deneb_00000.fit	14/11/13	14.4831 /11/2013		788.1729	6485.75439453...
03	betelguise_0000...	13/11/13	13.5784 /11/2013		789.2657	6485.75439453...

Select a region on the chart to take a measurement

Results are initially calculated using raw values and then formatted to the number of significant figures specified. Some calculated results may therefore not always reconcile with calculations made using already rounded values.

Use the scrollbar or resize the screen to see more of the displayed results.

Data can be copied from the text area (for subsequent pasting elsewhere) using the mouse, or via the right mouse menu options on the data grid.



Sequence	01	02	03
DateFraction			
ExpTime			
StartPixel	100.063	393.2849	150.3467
StartLamda	652.815002441406	652	
StartVelocity			
StartFlux	747.875761959895	779	
EndPixel	186.1686	480.926	236.1543
EndLamda	664.665100097656	664.665100097656	664.6651000
EndVelocity			

Select a region on the chart to take a measurement

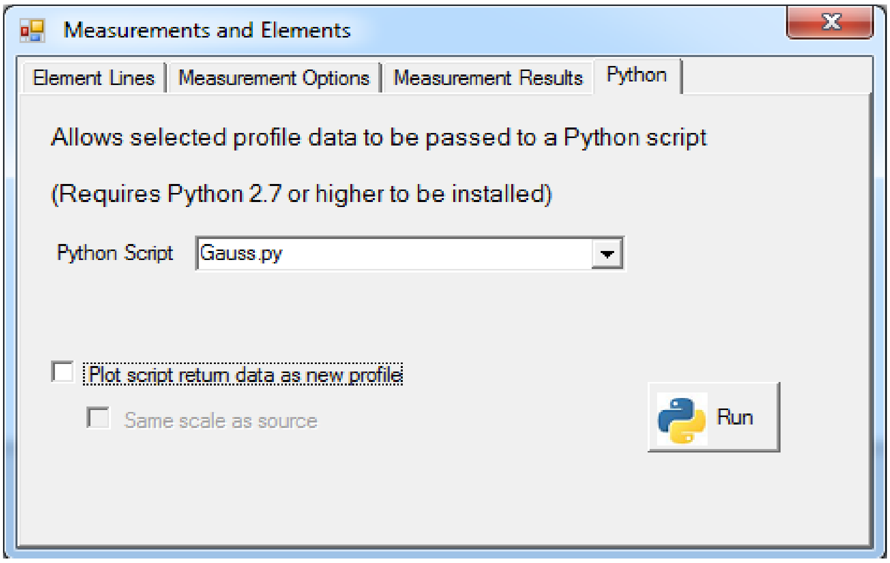
Note: The reported measurements will use cubic spline interpolation and may therefore differ slightly from the figures shown on the left hand status bar (that use linear interpolation).

2.13.5 Python tab

For advanced users. This tab allows selected profile data to be passed for a Python script by reading and writing files with a specific naming and format.

Python 2.7 needs to be installed. (Has not been tested with higher versions).

Script files need to be placed in the <BASS Install Path>\Scripts\Measure1d folder where some example *.py python scripts are provided.



Allows selected profile data to be passed to a Python script

(Requires Python 2.7 or higher to be installed)

Python Script: Gauss.py

☐ Plot script return data as new profile

☐ Same scale as source

2.14 Reference Spectrum

The Reference Spectrum screen is available from the toolbar or the main Tools menu.

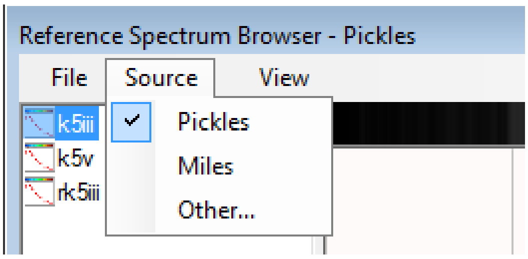
The screen will display a reference spectrum which can be added to a chart. A Reference spectrum is commonly used for comparison or to derive a corrected instrument response.

The Pickles library data files used in BASS are held in the …\Reference\Spectra folder underneath the installation folder and have been cropped to 300nm to 1000nm. The data originates from ESO.
https://www.eso.org/sci/facilities/paranal/instruments/isaac/tools/lib/index.html

2.14.1 Selecting a reference spectrum

By default, the Pickles Library is offered as the default source of reference files, but you can select Miles reference profiles from the Source menu.

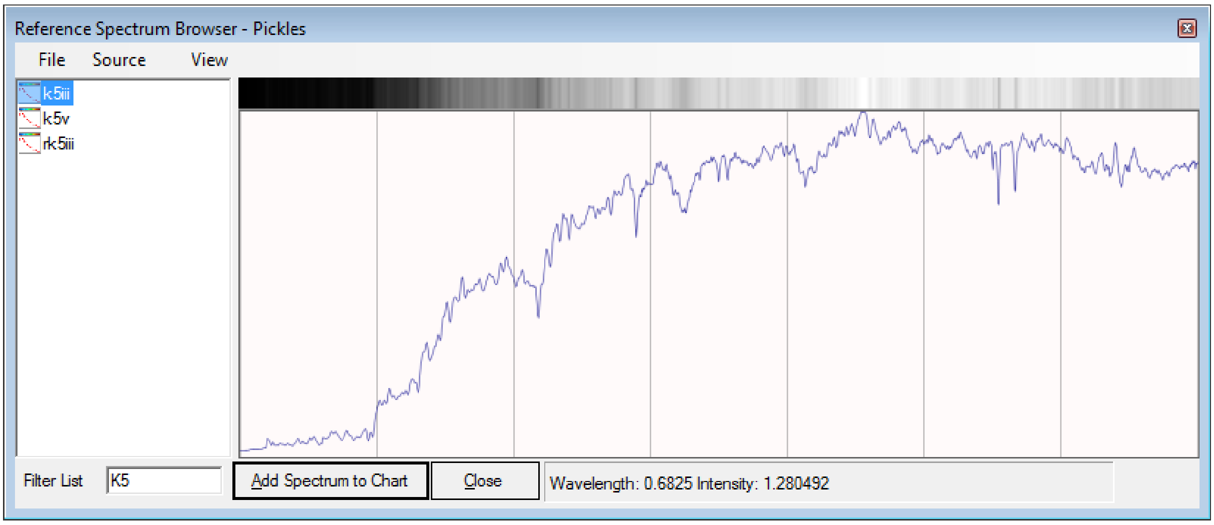
See the ink to the BASS Project Astrobodger Yahoo Group to get the Miles library
https://uk.groups.yahoo.com/neo/groups/astrobodger/links/all/Miles_Reference_spectra



Select the spectral class appropriate for your image from the list on the LH panel on the screen. (For example select A0v for a Vega image or K5iii for Aldebaran). The list is in order with the highest temperature 'o' and 'b' stars first.

Once a class has been selected, the screen will display a binned image view and preview a chart. Move the mouse over the chart to display the wavelength of a feature.

The list of spectral classes displayed can be filtered by keying into the "Filter List" text box on the bottom LH corner. Clear the textbox to show the complete list.



Filter List K5

Wavelength: 0.6825 Intensity: 1.280492

2.14.2 Adding reference spectra to the project

Once a stellar class has been selected, click on the Add Spectrum to Chart button on the bottom of the screen. This will add the reference spectrum to the main chart as an additional profile. Multiple reference spectra can be added to the main chart, if so desired.

Reference spectra from other sources can be added to the project as per the normal add image process.

Click the Close button to close the screen.

Note: Not all stellar classes are provided in the Pickles library. An intermediate spectral class can be obtained by selecting two references and averaging them i.e.

an A2i and A2v can be stacked to provide a usable A2iii reference spectrum.

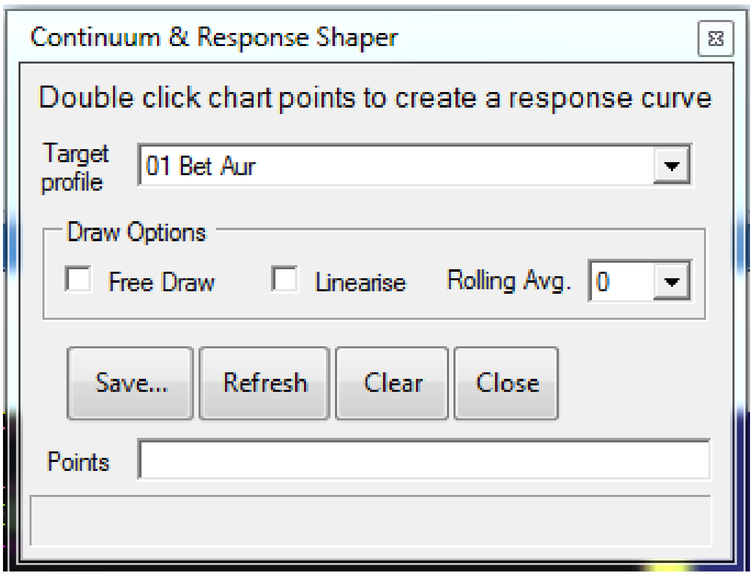
2.15 Continuum & Response Shaper

This function is available via the main Tools menu or toolbar icon .

The purpose of this function is to create a response correction from points double clicked on the chart.

There are two main types of response corrections that can be created and stored against spectral profiles:

- Instrument Response correction – This is normally created by dividing a raw profile with a reference profile and smoothing the result. Profiles need to have been calibrated before an instrument response is carried out.
- Continuum Removal – This is also known as normalisation or rectification and is created by dividing the raw profile with a smoothed version of itself.



Double click chart points to create a response curve

Target profile: 01 Bet Aur

☐ Free Draw ☐ Linearise Rolling Avg. 0

Points:

There are many ways of managing the correction data. You can save the correction as a separate response DAT file (as traditionally used by many other applications), or save as a set of cubic spline points (either within the profile’s image information *.info.bas, or centrally within a master *ResponseCurves.dat* file).

2.15.1 Screen functionality

The screen controls are described below

Target profile – this drop down list is used to select which of the open profiles that the correction will be saved against. (Not required when saving to DAT file or master Response ResponseCurves.dat)

Free Draw - this check box will allow free hand points not following the intensity profile to be added

Linearise - this checkbox can be used to force existing points within the selection to be in a straight line. Tick before selecting a region.

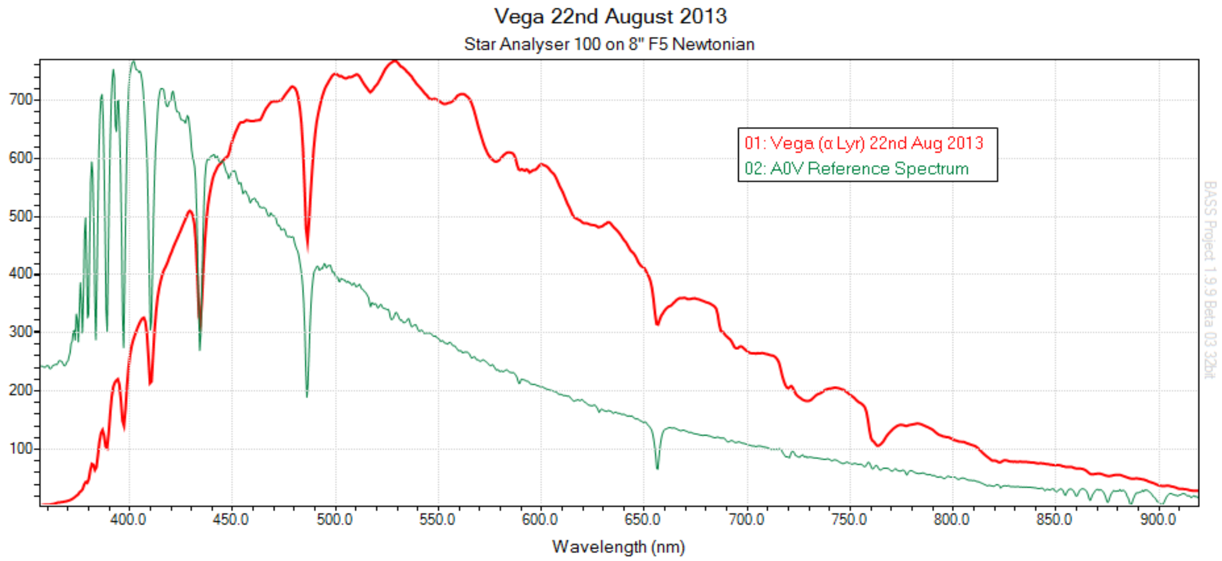
Rolling Avg. - this 'Rolling Average' drop-down will inserts the average value of the specified number of neighbours. This acts as a low pass filter on-the-fly.

More details are provided in the “Save Curve Options” sub heading.

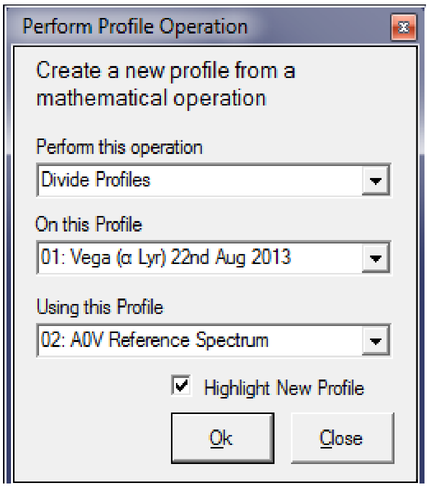
2.15.2 Instrument Response creation process

This process will save the correction as a set of cubic spline points that are stored with the profile (in the*.info.bas file).

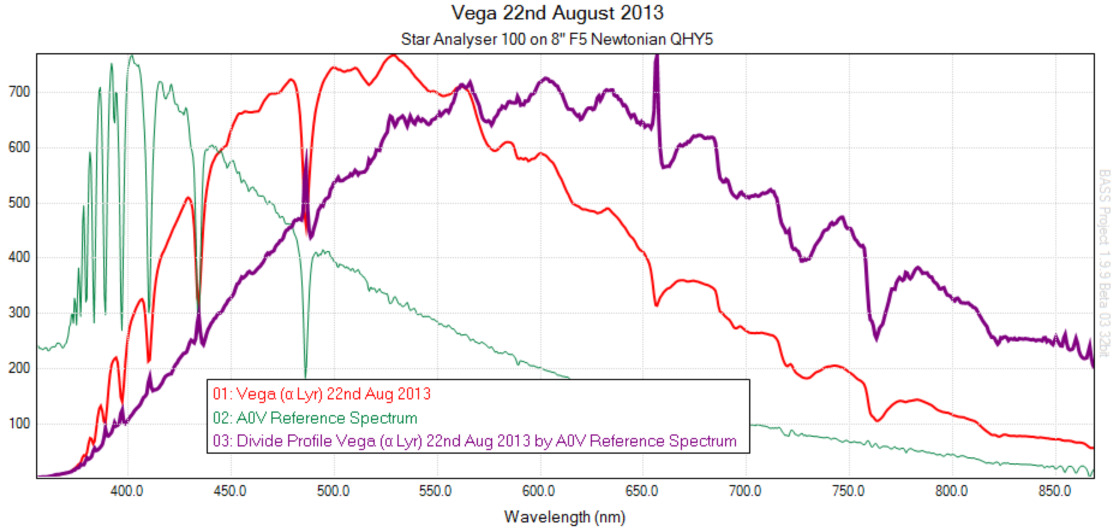
- Load a calibrated but uncorrected target profile (or disable existing correction).
- Add the reference spectrum for the target spectral class (e.g. A0V for Vega).



- Use the Operations screen to Divide the target profile by the reference spectrum



This creates a new profile for the divided result



- Open the Continuum & Response Shaper screen. The colour of the cursor and status bar text become orange to indicate the chart is in ‘continuum shaper mode’.

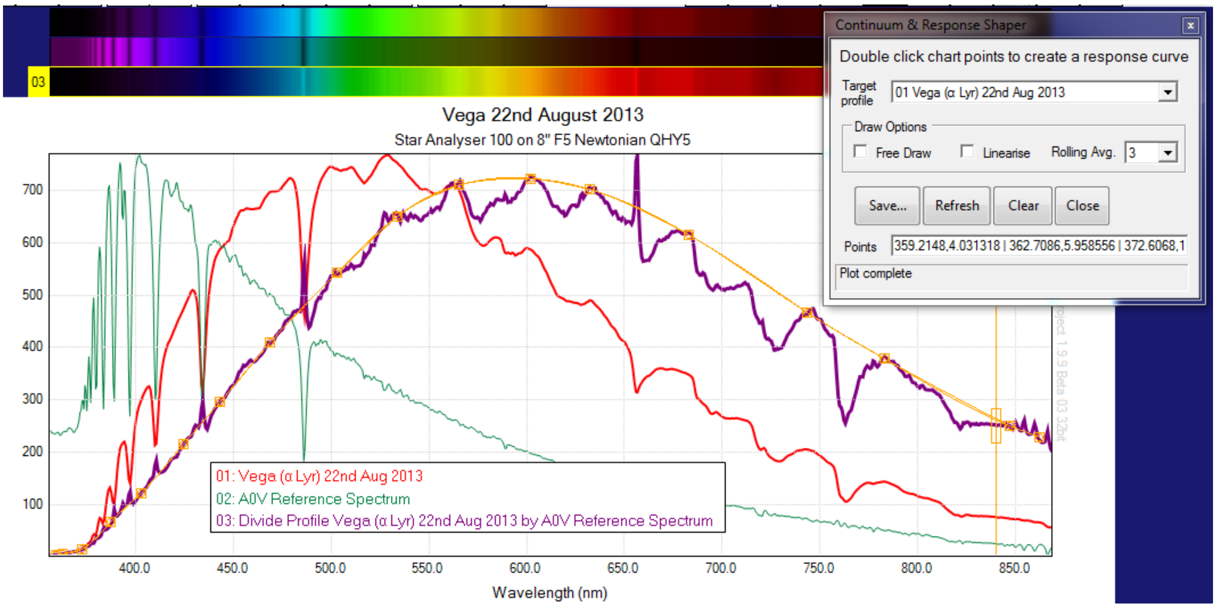
Move the screen around so that the divided profile is not obscured

- Click on the image strip of the divided profile to make it the active profile

- Starting from the left, double click on points along the divided profile that fall on a smooth curve that avoids sharp peaks & troughs. As the cursor will track the intensity, you just need to move along the x axis.

Note: Double click on an existing point to remove it.

Note: Increase the chart width to be more accurate when setting the data points



Double click chart points to create a response curve

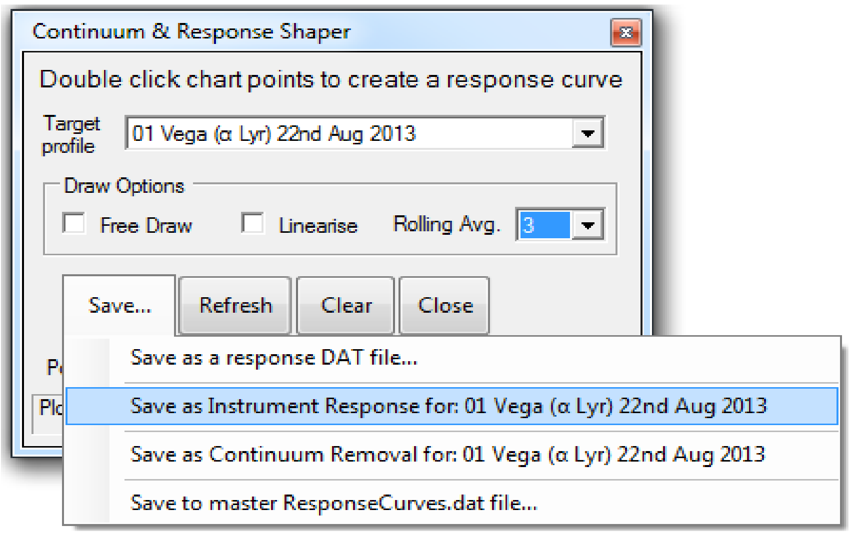
Target profile: 01 Vega (α Lyr) 22nd Aug 2013

Draw Options: ☐ Free Draw ☐ Linearise Rolling Avg. 3

Points: 359.2148,4.031318 | 362.7086,5.958556 | 372.6068,1

Plot complete

- Click Refresh to clean up the curve if necessary
- Once you are happy with the curve, set the target profile drop down list to the target (Vega) image, then press the Save button and select the ‘Save as Instrument Response for: ’ option.

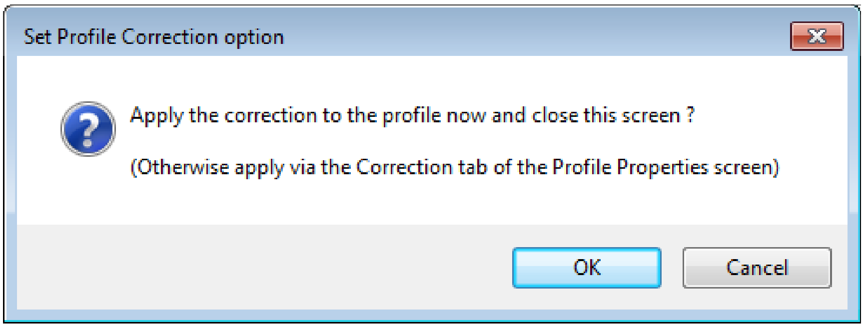


Double click chart points to create a response curve

Target profile: 01 Vega (α Lyr) 22nd Aug 2013

Draw Options: ☐ Free Draw ☐ Linearise Rolling Avg. 3

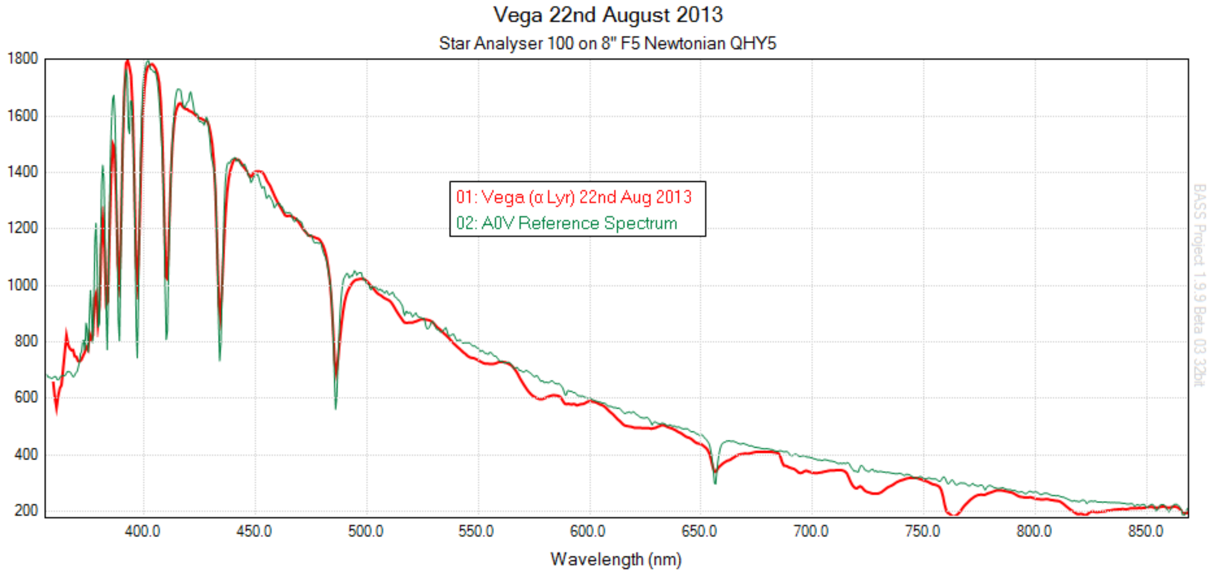
You will then be prompted to apply the saved response to the target.



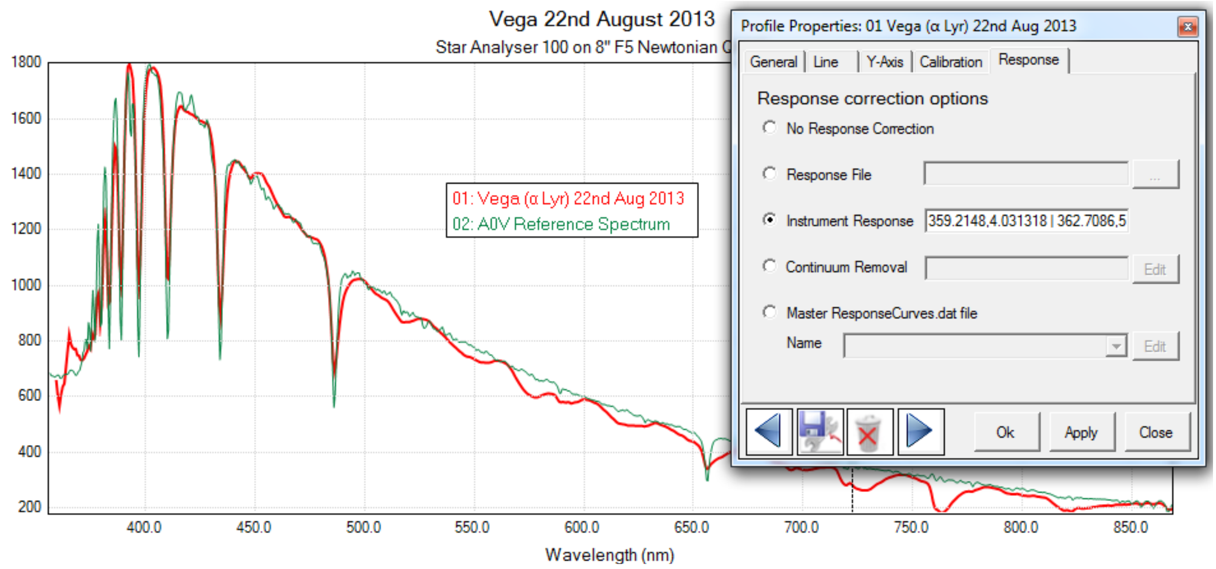
Apply the correction to the profile now and close this screen ?

(Otherwise apply via the Correction tab of the Profile Properties screen)

Press Ok to apply the change. The Vega profile now follows the shape of the reference spectrum. The divided profile is no longer required so can be removed.



If Cancel was pressed then the results of the instrument response correction are only visible once selected in Profile Properties.



● Instrument Response 359.2148,4.031318 | 362.7086,5

See how the correction can be disabled using the No Response Correction option.

2.15.3 Continuum Removal process

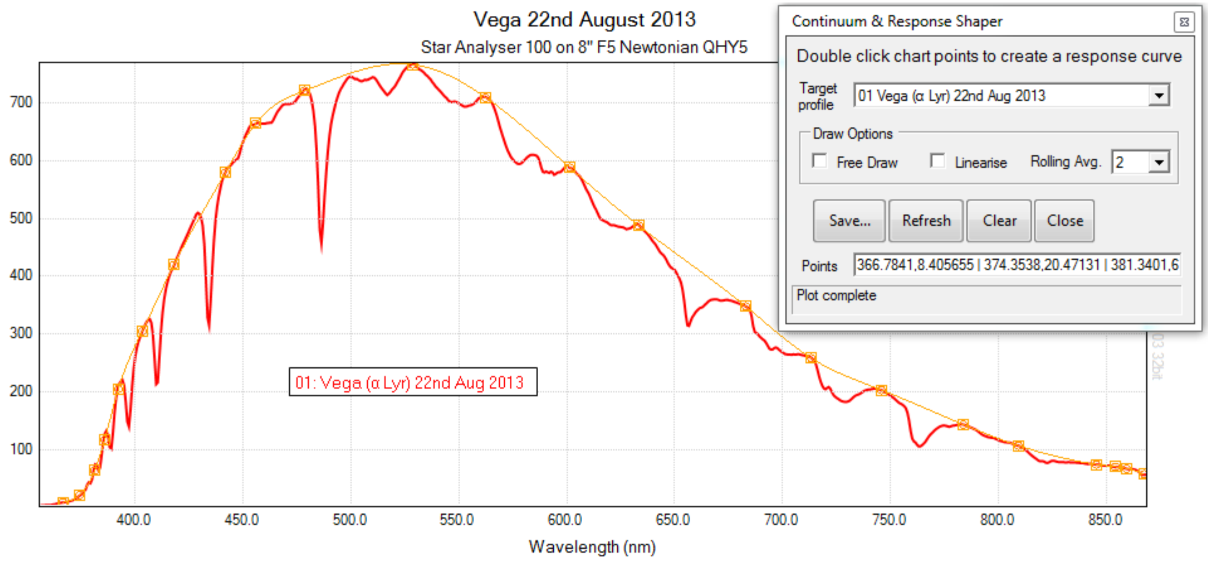
- Load a calibrated but uncorrected profile (or disable existing response correction). No reference spectrum file is needed here.
- Open the Continuum & Response Shaper screen. Move it so the profile is not obscured

- Starting from the left, double click on points along the profile that fall on a smooth curve that avoids sharp peaks & troughs. As the cursor tracks the intensity, you just need to move along the x axis.

> *Note: Double click on an existing point to remove it.*

> *Note: You may wish to increase the chart width to be more accurate when setting the data points*

- Click Refresh to clean up the curve if necessary. As per the screenshot below, the continuum correction curve and points double clicked are shown in orange.



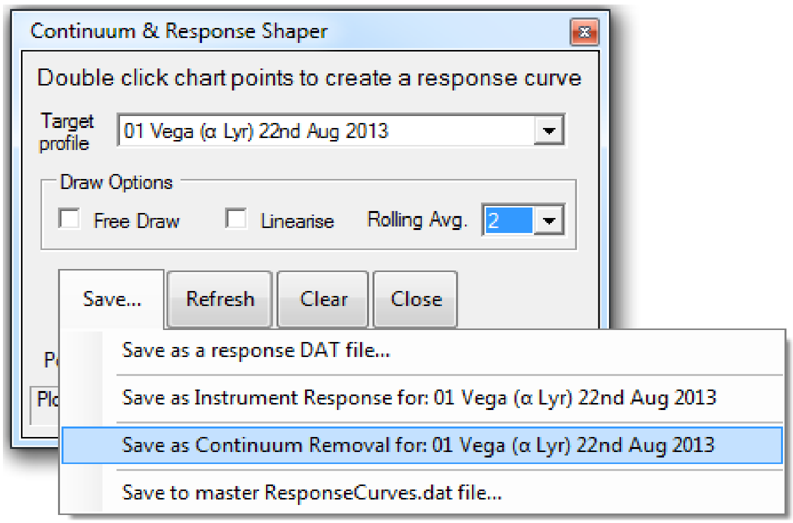
Target profile: 01 Vega (α Lyr) 22nd Aug 2013

Rolling Avg.: 2

Points: 366.7841,8.405655 | 374.3538,20.47131 | 381.3401,6

Plot complete

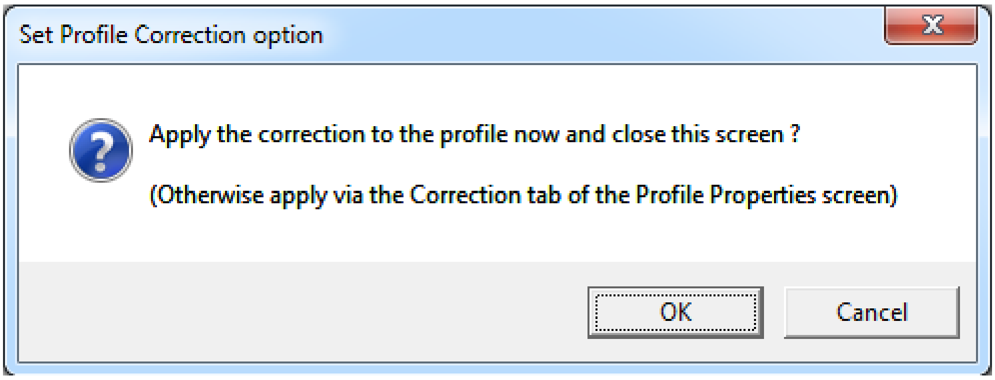
- Once you are happy with the curve, set the target profile drop down list, click the Save button and then select the 'Save as Continuum Removal for:' option.



Target profile: 01 Vega (α Lyr) 22nd Aug 2013

Rolling Avg.: 2

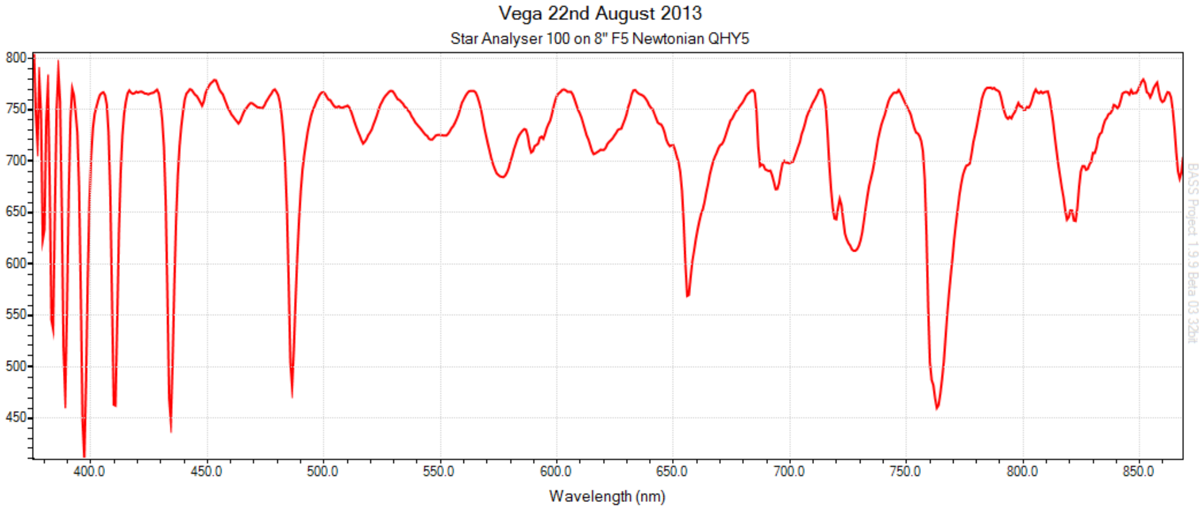
- Press Ok when prompted to apply the saved response to the target.



Apply the correction to the profile now and close this screen ?

(Otherwise apply via the Correction tab of the Profile Properties screen)

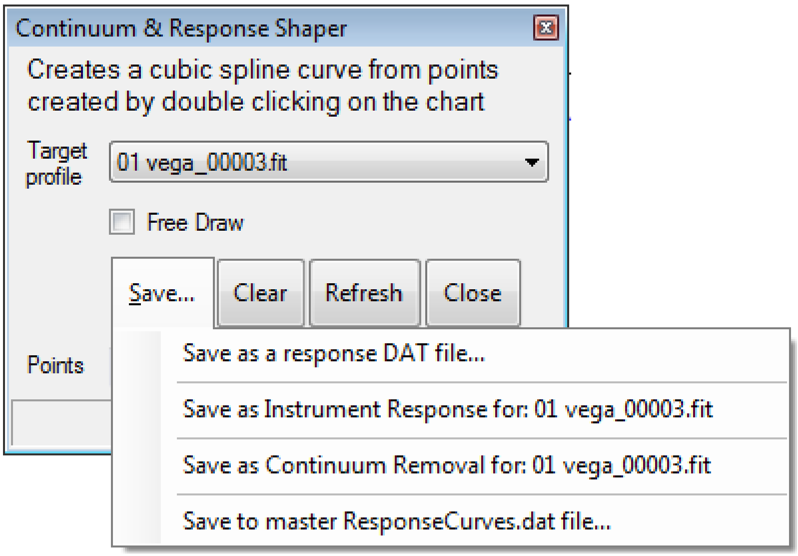
Click OK to see the profile with the continuum removed. If necessary, adjust the x axis crop range to exclude spurious results at the extreme ends of the profile.



The results of the Continuum Removal or Instrument Correction are visible when selected in the Correction tab of the Profile Properties screen.

2.15.4 Save Curve options

When the Save button is pressed, four options are offered:



Continuum & Response Shaper

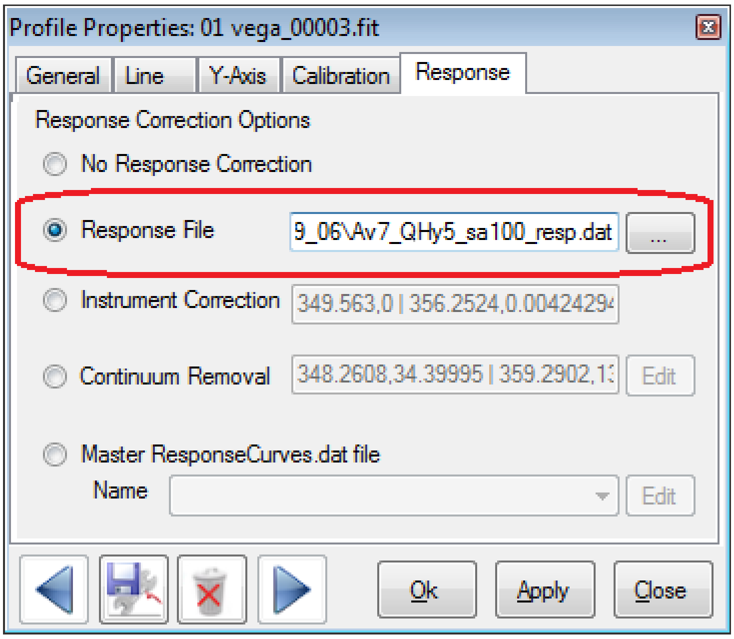
Creates a cubic spline curve from points created by double clicking on the chart

Target profile: 01 vega_00003.fit

☐ Free Draw

- Save as Response DAT file – This is the ‘traditional’ option and will prompt for a file name to save the correction curve as a DAT profile that can be then linked to the profile or even used for other applications.

  To apply this correction, select the Response File option from the Correction tab of the Profile Properties screen, then browse or enter the file & path of the response file.



Profile Properties: 01 vega_00003.fit

Response Correction Options

○ No Response Correction

● Response File: 9_06\Av7_QHy5_sa100_resp.dat

○ Instrument Correction: 349.563,0 | 356.2524,0.0042429

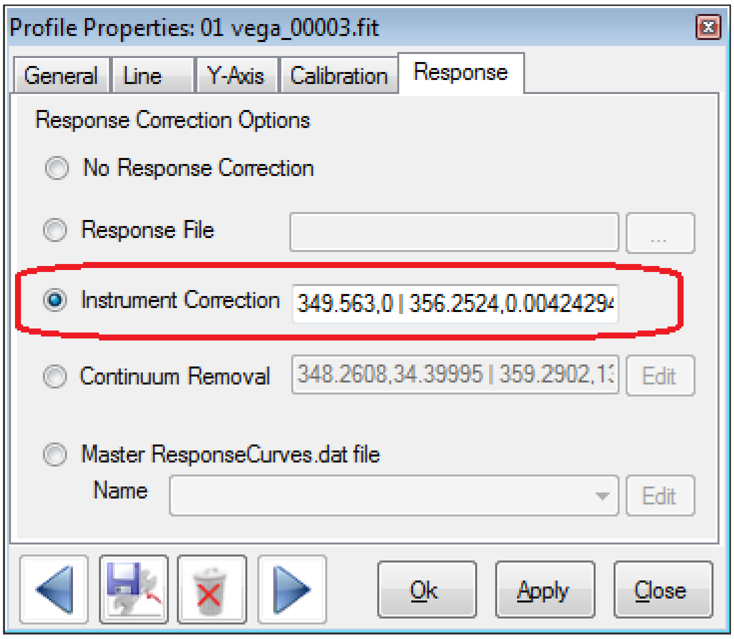
○ Continuum Removal: 348.2608,34.39995 | 359.2902,1

○ Master ResponseCurves.dat file

Name:

- Save as Instrument Response for profile <profile name> – Select an open profile from the drop down list. Press this button to store points in the profile’s *info.bas image information file. This will prompt to overwrite if a correction exists

  To apply this correction, select the Instrument Correction radio button from the Correction tab of the Profile Properties screen.


Profile Properties: 01 vega_00003.fit

Response Correction Options

○ No Response Correction

○ Response File

● Instrument Correction: 349.563,0 | 356.2524,0.0042429

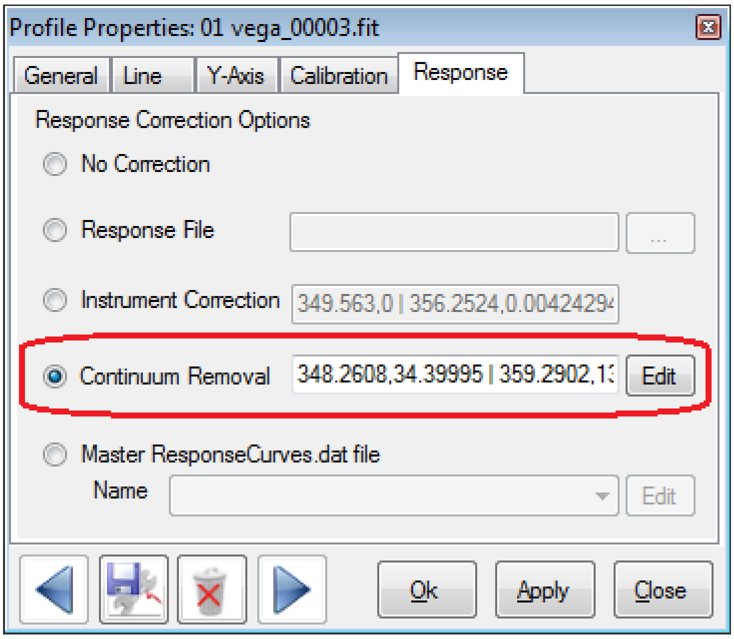
○ Continuum Removal: 348.2608,34.39995 | 359.2902,1

○ Master ResponseCurves.dat file

Name:

- Save as Continuum Removal for profile <profile name> - Select an open profile from the drop down list. Press this button to store points in the profile’s info.bas image information file. This will prompt to overwrite if a correction exists

  To use this correction, select the Continuum Removal radio button from the Correction tab of the Profile Properties screen.


Profile Properties: 01 vega_00003.fit

Response Correction Options

○ No Correction

○ Response File

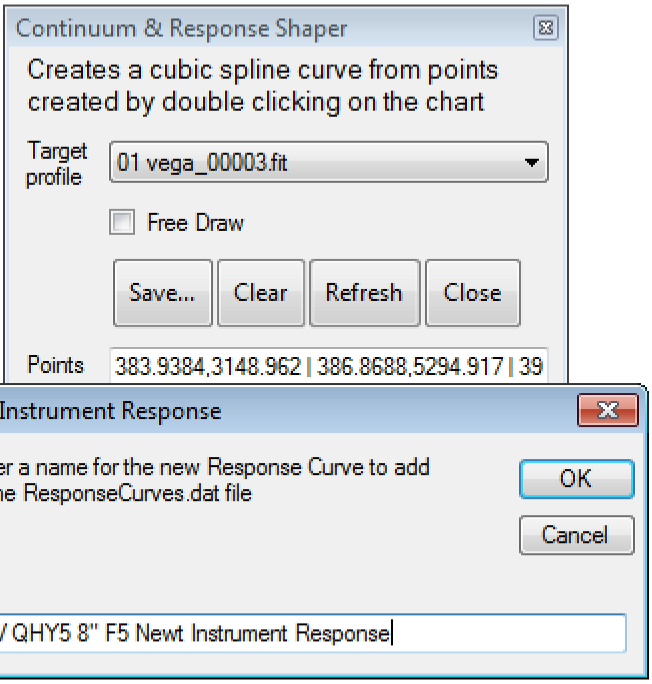
○ Instrument Correction: 349.563,0 | 356.2524,0.0042429

● Continuum Removal: 348.2608,34.39995 | 359.2902,1

○ Master ResponseCurves.dat file

Name:

- Save to Master ResponseCurves.dat file - This will prompt for a response curves name and then append the points to a new line at the end of the master response curves data file (ResponseCurves.dat). This makes it easy to be reused for other profiles



Creates a cubic spline curve from points created by double clicking on the chart

Target profile: 01 vega_00003.fit

☐ Free Draw

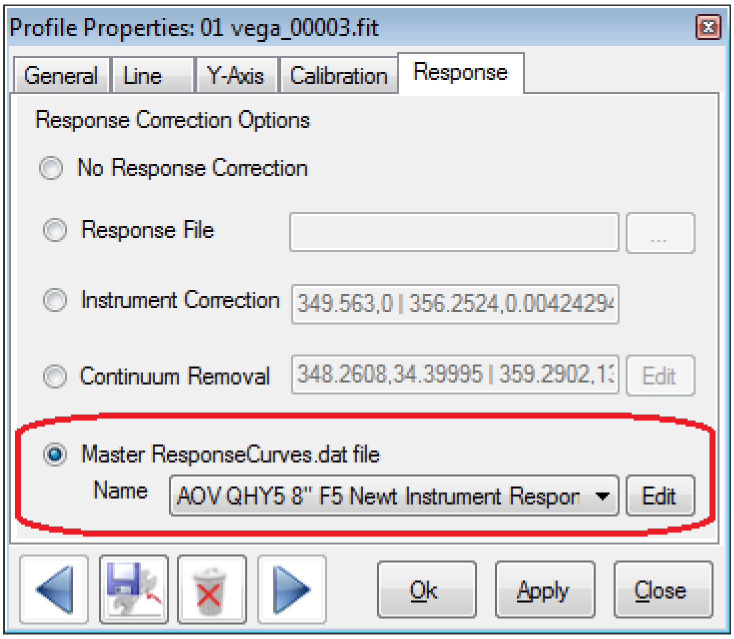
Points: 383.9384,3148.962 | 386.8688,5294.917 | 39

Enter a name for the new Response Curve to add to the ResponseCurves.dat file

AOV QHY5 8" F5 Newt Instrument Response

.

To apply a response curve from ResponseCurves.dat to a profile, select the ‘Master ResponseCurves.dat’ radio button from the Correction tab of the Profile Properties screen and then select from the dropdown list.



Response Correction Options

○ No Response Correction

○ Response File

○ Instrument Correction: 349.563,0 | 356.2524,0.0042429

○ Continuum Removal: 348.2608,34.39995 | 359.2902,1:

● Master ResponseCurves.dat file

Name: AOV QHY5 8" F5 Newt Instrument Respon

The contents of the points text box are available to cut/paste into your own text files if you so wish.

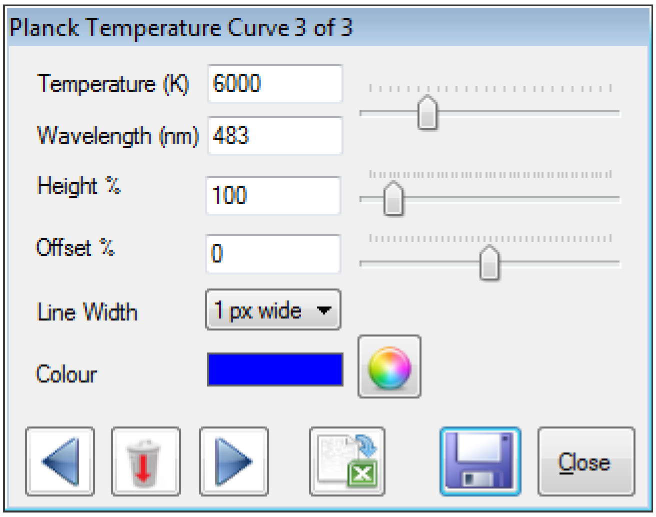
Note: To redo a response correction, first turn off any existing correction by selecting the ‘No Response’ option in the Correction Tab of the Profile Properties screen.

2.16 Planck Temperature Curve

The Planck temperature tool is available via the main Tools menu or toolbar .

The classification of a star depends not only on the size and elemental composition, but also the surface temperature.

The Plank Curve displays the distribution of irradiance with wavelength and shows that the peak wavelength is determined by the surface temperature. The shape of the continuum of a stellar profile is governed primarily by its temperature as if it was a “black body”.



Planck Temperature Curve 3 of 3

Temperature (K) 6000

Wavelength (nm) 483

Height % 100

Offset % 0

Line Width 1 px wide

Colour

The screen contains the following features:

- Temperature – Generates a Planck curve for the specified temperature (degrees Kelvin)
- Wavelength – Generates a Planck curve for the peak wavelength entered
- Temperature – Slider provides an alternative method to set the temperature (& peak wavelength)
- Height textbox – Specifies the height of the Planck curve peak drawn on the chart. This makes the curve larger or smaller. 100% will fit to the height of the chart.
- Height – Slider provides an alternative method to set the height.
- Offset – Textbox specifies the vertical position of the Planck curve drawn on the chart. This moves the Planck curve up or down.
- Offset – Slider provides an alternative method to set the offset.
- Line Width – Drop down list allows the thickness of the line to be set. A ‘0’ value will hide the line.
- Colour icon – The button opens a Windows colour picker dialog allowing the display colour of the Planck curve to be changed.
- Previous icon – Button navigates to the previous Planck curve (when applicable). The form caption displays the position of the current item in relation to the number of Planck curves (e.g. item 2 of 3 total)

- Delete button – This prompts for confirmation before removing Planck curve.

- Next button – This navigates to the next Planck curve (when applicable). The form caption displays the position of the current item in relation to the number of Planck curves (e.g. item 2 of 3 total)

- Export icon – Button prompts for a filename to save the active Planck curve as a DAT profile. Having the Planck curve available as a profile allows operations such as division to be performed.

- Save icon – Button adds the Planck curve to the chart; otherwise the curve will be removed when the chart is next redrawn.

- Close – Button closes the screen.

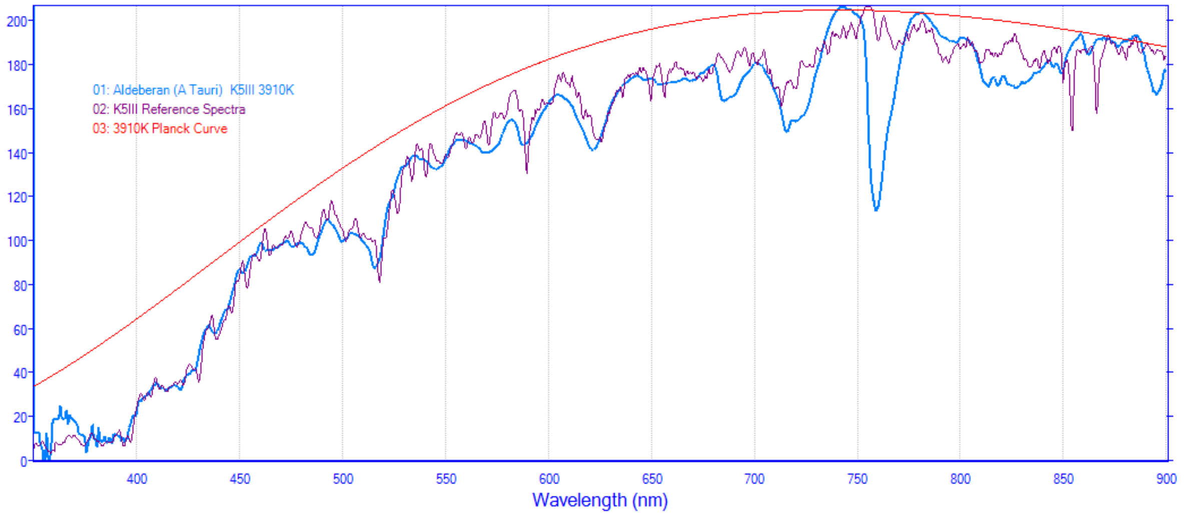
2.16.1 Relationship of temperature and peak wavelength

The temperature and peak wavelength textbox values are related as below

$$\lambda_{max} = 2897820 / T$$

Where T is the temperature in degrees Kelvin and λ_{max} is the peak wavelength in nanometres.

E.g. Type in 400 nm wavelength to update temperature to 7244.6K (and vice-versa).



2.16.2 Fitting the Planck curve

The Height and Offset textboxes and horizontal sliders are provided to help match the amplitude and level of the Planck cure with your spectral profile. If you need more movement than the slider allows, just enter the number in the textbox.

The process can be repeated with different stellar classes. Matching the Plank curve gets more difficult with blue stars as the peak wavelength is beyond the useful response. The trick is then to try to match on the shape of the descending curve.

Editing the temperature field until a best match is found is a technique that can be used to help determine the temperature of an unknown star.

The predicted temperature, however, does not always fit as many other factors can come into play.

Note: Fitting the curve is easier if source profile y-axis scaling shows 0 on the y-axis.

2.16.3 Managing Planck curves

The screen shows the details of the current Planck curve and provides the ability to navigate, add, edit and hide multiple curves.

Planck curves are listed in the Chart Legend in the descending order of Temperature (i.e. hot curves are displayed above cooler curves).

The Temperature field uniquely identifies each curve so only one Planck curve is allowed per Temperature. If you edit a curve to use an existing Temperature then the previous curve will be overwritten. If you edit the Temperature and Save then a new curve is created using the new Temperature. The original will still exist but is easily discarded using the Delete button.

The Line Width drop down allows the width to be set or the curve to be hidden

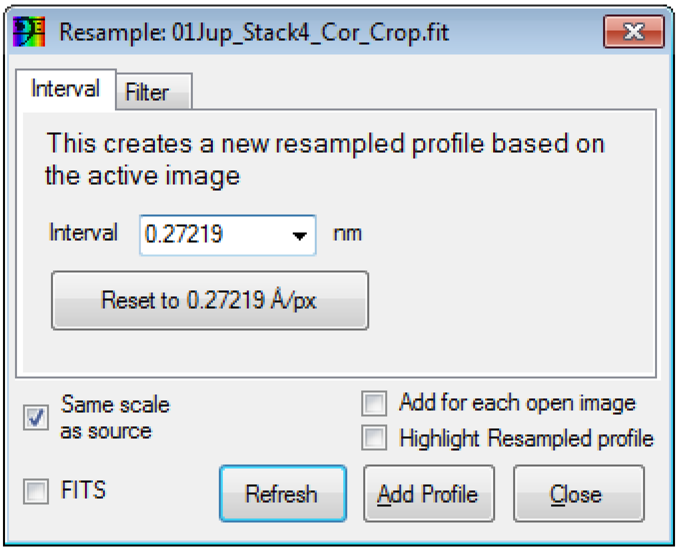
After a Planck curve is saved, the list is resorted and the first curve is selected.

2.17 Resample Profile

The Resample function is available from the main toolbar or under the Tools menu. You must select a profile before invoking this function. In addition to resampling profiles, this screen also allows filters to be applied.

The chosen profile that will be the source of the resample is shown in the screen caption. The source profile will NOT be overwritten. This function can only add one or more new profiles.

The screen provides Interval and Filter tab headers


Resample: 01Jup_Stack4_Cor_Crop.fit

This creates a new resampled profile based on the active image

Interval 0.27219 nm

☑ Same scale as source

☐ Add for each open image

☐ Highlight Resampled profile

☐ FITS

2.17.1 Interval tab

This allows the sampling interval to be set that will be applied to a cubic spline curve.

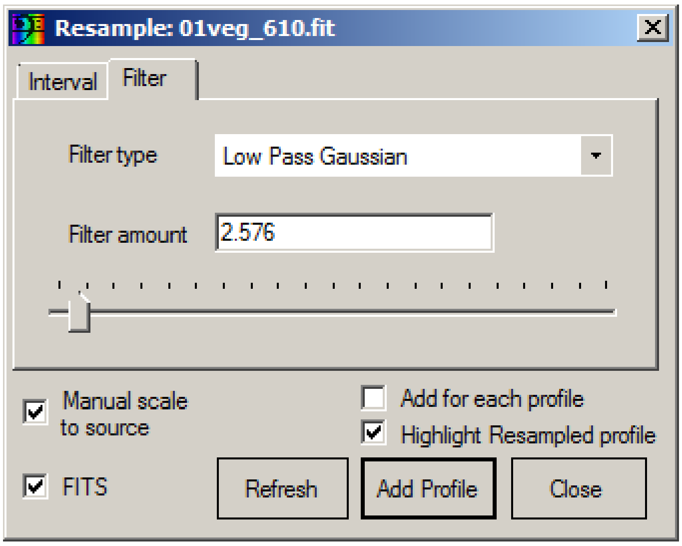
Interval – a drop down list containing a list of interval values. If the profile is calibrated then the unit will be nanometers, otherwise it will be pixels. You can also type in values that are not in the list.

Reset to [X] – button that resets the interval to the current average interval X.

A smaller interval results in a larger number of points, e.g. setting to 0.5 for an uncalibrated profile will double the number of points.

2.17.2 Filter tab

This screen provides options for applying low or high pass filtering to the profile. A Filter can be used in combination with the Sampling Interval value.


Resample: 01veg_610.fit

Filter type Low Pass Gaussian

Filter amount 2.576

☑ Manual scale to source

☐ Add for each profile

☑ Highlight Resampled profile

☑ FITS

Filter Type – A drop down list containing the following filter types

- [none] – no filter will be applied
- Low Pass – use for general smoothing
- Low Pass Gaussian – finer low pass filtering
- High Pass – Signal minus Low Pass value
- High Pass Gaussian – Signal minus Low Pass Gaussian value

Filter amount - a textbox to enter the Filter value. Higher values increase the effect of the filter.

Filter Slider – a horizontal slider bar provides an alternative means of setting the Filter value. Allows changes to be seen in real-time. Use the forward and back arrow keys for fine changes

2.17.3 Common settings

The controls on the base of the screen apply to both the Interval and Filter tab headers

Manual scale to source – A checkbox that overrides the default autoscaling of the Y-axis. This manually scales the filtered profile to the same scale as the source. The scaling values can be seen in the Y-Axis tab of the Profile Properties screen.

Note: The Manual scale checkbox may be better turned off for high pass options.

Linear Interpolation – a checkbox to use linear instead of cubic spline interpolation.

FITS – A checkbox to set the format of newly created profile(s) as FITS format. The ‘off’’ setting will use a DAT format.

Add for each open image – a checkbox that will create an additional resampled profile for every open image, when ticked.

Refresh – a button to update the resampled profile after changes have been made.

Add Profile – a button to add a new resampled profile(s) to the chart and then close the form. The caption of the new profile is concatenated using the original profile name.

Highlight Profile – a checkbox to show the interpolated profile bold (as a thicker line)

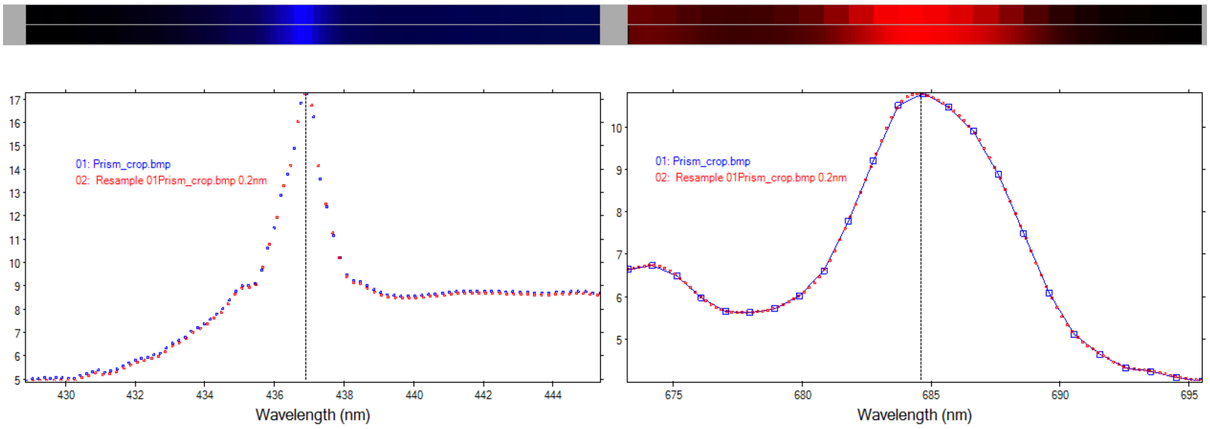
Close – close the form without adding a new profile

2.17.4 Producing a linear wavelength profile

Interpolating a calibrated profile will generate a constant wavelength interval between data points. This is useful when the source has a very non-linear calibration (e.g. a prism spectrum).

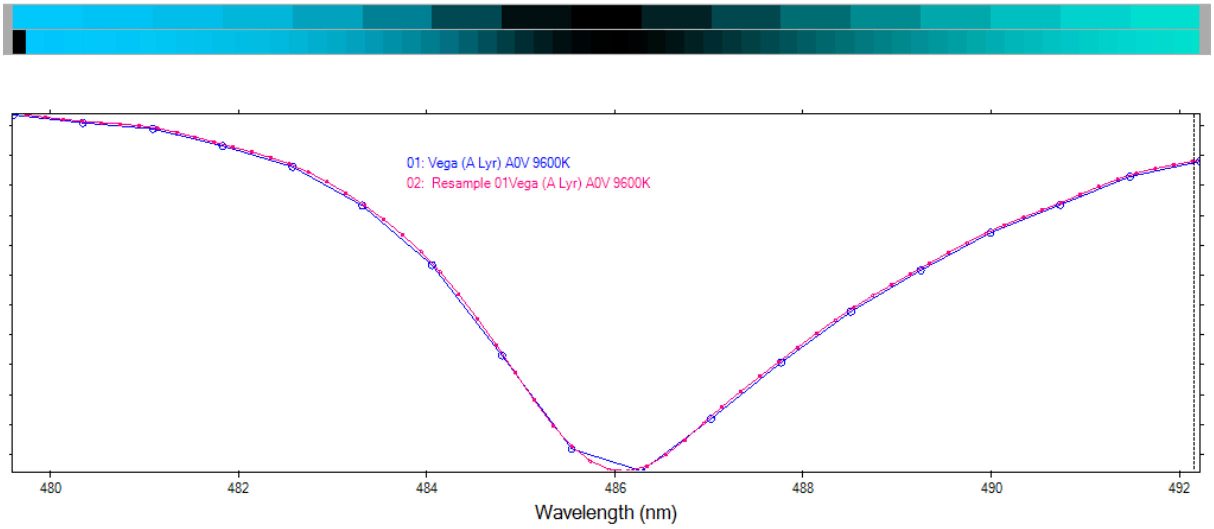
This function is used by the Save 1D function to create a linear profile when the source profile has a non-linear wavelength calibration.

In the example of a prism spectrum below, the raw blue points are more widely spaced at the red end of the spectrum. The resampled red points are constantly spaced.



2.17.5 Increasing the sampling interval for interpolation

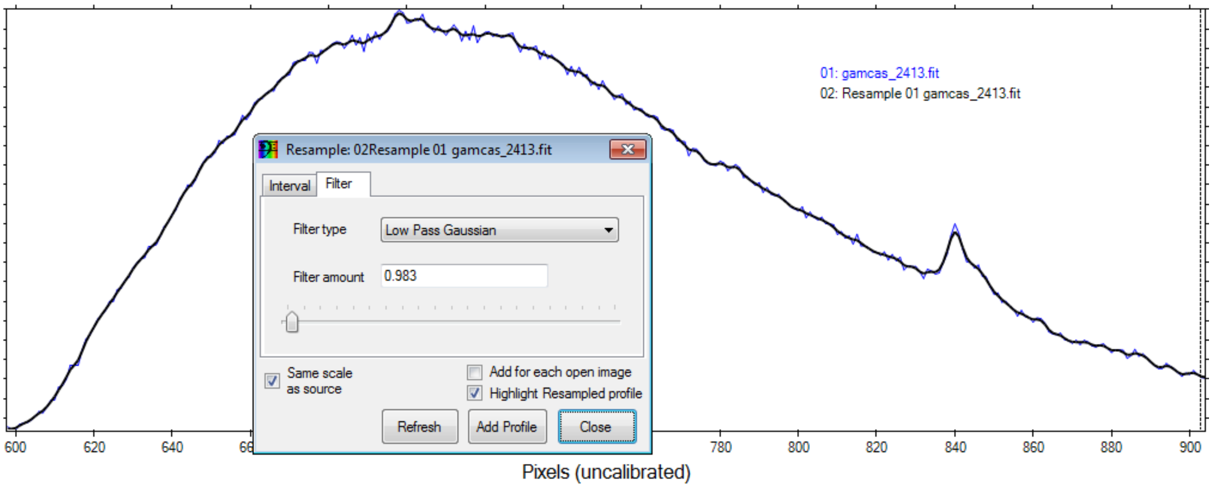
Increasing the interval can have a benefit in a smoother curve making the interpolated min/max easy to visualise.



Note: Choosing too small an interval can just make the profiles unnecessarily large and slow things down.

2.17.6 Using the Low Pass Gaussian option to smooth out noise

Subtle filtering using the Low Pass Gaussian option can be used to reduce the noisiness of a profile.



Filter type: Low Pass Gaussian

Filter amount: 0.983

☑ Same scale as source

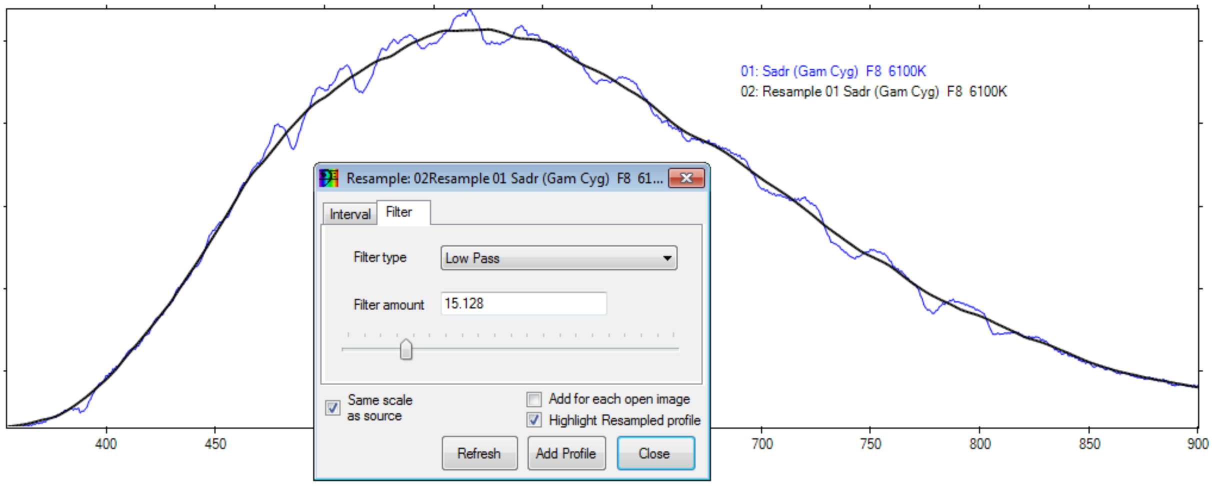
☐ Add for each open image

☑ Highlight Resampled profile

This is a useful tool which can be applied to comparison spectra, to bring a high resolution spectrum to a more appropriate resolution.

2.17.7 Using the Low Pass option to create a continuum

Substantial Low Pass filtering on a profile can be used to generate a smooth continuum that could be used to derive a continuum removal response.



Filter type: Low Pass

Filter amount: 15.128

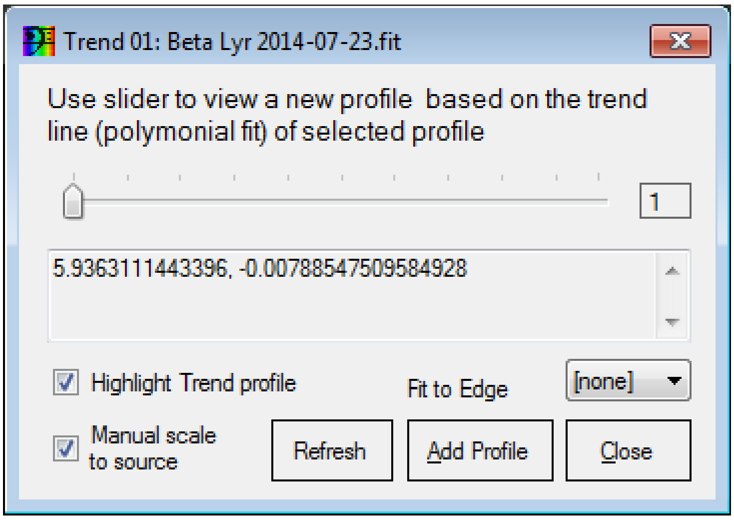
☑ Same scale as source

☐ Add for each open image

☑ Highlight Resampled profile

2.18 Trend Line

The Trend Line function is available under the Tools menu. It basically creates a new profile by applying a linear or polynomial regression from the source



Trend 01: Beta Lyr 2014-07-23.fit

Use slider to view a new profile based on the trend line (polymonial fit) of selected profile

1

5.9363111443396, -0.00788547509584928

☑ Highlight Trend profile

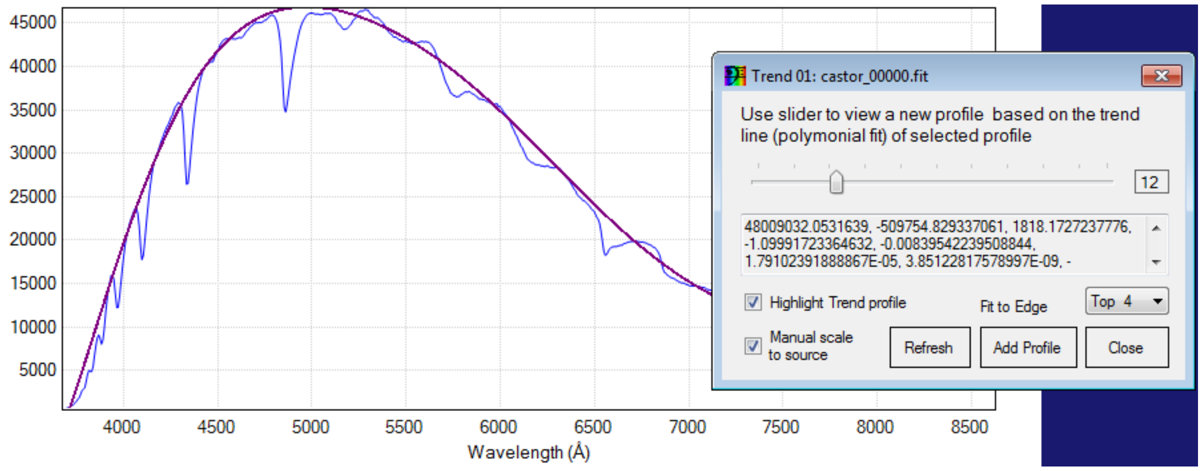
Fit to Edge: [none]

☑ Manual scale to source

The horizontal slider sets the degree of the polynomial (1=linear) which is displayed in the box on the right. The coefficients are displayed below the slider.

2.18.1 Trend line for response correction

The Fit To Edge drop down list may be helpful when using this function to create a response correction.



Trend 01: castor_00000.fit

Use slider to view a new profile based on the trend line (polymonial fit) of selected profile

12

48009032.0531639, -509754.829337061, 1818.1727237776, -1.09991723364632, -0.00839542239508844, 1.79102391888867E-05, 3.85122817578997E-09, -

☑ Highlight Trend profile

Fit to Edge: Top 4

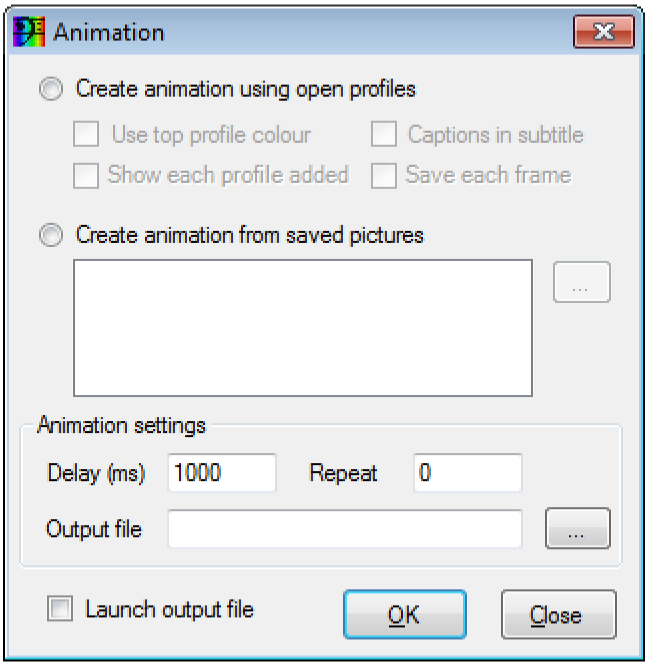
☑ Manual scale to source

Pressing Add Profile will add the curve as a new DAT profile to the project.

2.19 Animation

The Animation function is available from the toolbar icon 🎞 or the Tools menu. This will create an animated GIF file from either open profiles or a set of saved pictures.

This function uses the GIF animation component created by gOODiDEA.NET that is licensed under The Code Project Open License (CPOL)

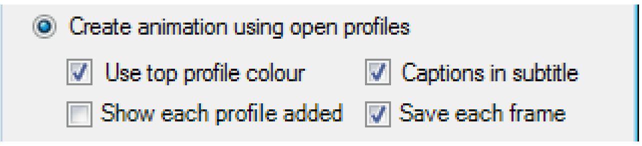


○ Create animation using open profiles
☐ Use top profile colour
☐ Captions in subtitle
☐ Show each profile added
☐ Save each frame
○ Create animation from saved pictures
Delay (ms) 1000
Repeat 0
☐ Launch output file

2.19.1 Create animation using open profiles

Use this option button to specify that open profiles in the current BASS project will be animated. The details of each profile, such as colour, the displayed caption and animation sequence are defined in the Profile Properties screen.

The dimensions and colour of the GIF file created will be the same as the chart and can be modified using Chart Settings.



● Create animation using open profiles
☑ Use top profile colour
☑ Captions in subtitle
☐ Show each profile added
☑ Save each frame

- Use top profile colour – a checkbox to make all frames use the same colour (as the first profile).

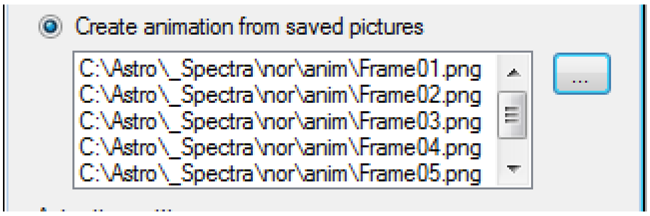
- Show each profile added – a checkbox that will add successive profiles to the chart. (Only a single profile is displayed at once otherwise).

- Captions in sub title – when checked, the legend is hidden and the caption of each profile is displayed in the sub title area above the chart. Obviously, any existing sub title won't be displayed in the animation. When this option is not checked, profile caption is displayed at the legend start position

- Save each frame – a checkbox that will save each frame to a file. Each file will named 'Frame + <profile sequence>' and will be saved in the same path as the output GIF file. A warning will be given when overwriting frame*.png files. Best to manually clear out existing files first.

2.19.2 Create animation from saved pictures

Use this option button to specify that picture files selected will be animated. Using picture files can be more complex, but ultimately allows you greater control to modify each picture in a graphics tool prior to animation.



● Create animation from saved pictures

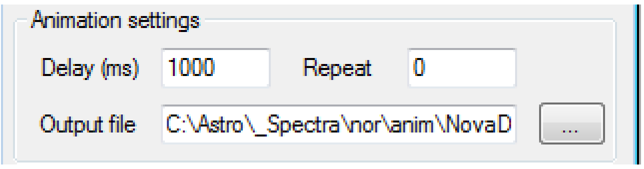
C:\Astro_Spectra\nor\anim\Frame01.png
C:\Astro_Spectra\nor\anim\Frame02.png
C:\Astro_Spectra\nor\anim\Frame03.png
C:\Astro_Spectra\nor\anim\Frame04.png
C:\Astro_Spectra\nor\anim\Frame05.png

- Pictures list box – a read only list box that is populated by files selected using the adjacent browse button. Pictures are processed in alphabetical order.

  Files can be removed from the list by selecting and pressing the Del (delete) key.

- Picture browse - a button to browse for picture files to be animated.

2.19.3 Animation settings panel



Animation settings

Delay (ms) 1000

Repeat 0

Output file C:\Astro_Spectra\nor\anim\NovaD

This contains GIF file options.

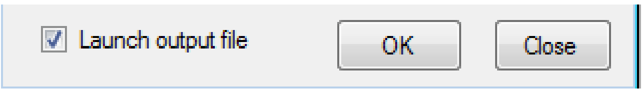
- Delay – a textbox to specify the delay (in milliseconds) between frames. Default value is 1000ms (= 1 second).

- Repeat – a textbox to specify the number of times the GIF file will repeat the set of frames. A value of 0 will repeat forever.

- Output file – a textbox containing the file and path of the GIF file to be created.

- File browse - a button to browse for the file and path of the output file.

2.19.4 Remaining screen controls



☑ Launch output file

- Launch output file – a checkbox that will start a Windows process to run the animated GIF file when OK is pressed. Within Windows. a GIF file must be associated with an application capable of playing an animated GIF (e.g. Internet Explorer) otherwise no animation will be seen.

- Ok – a button to initiate the creation of the animated GIF file in the Output file location.

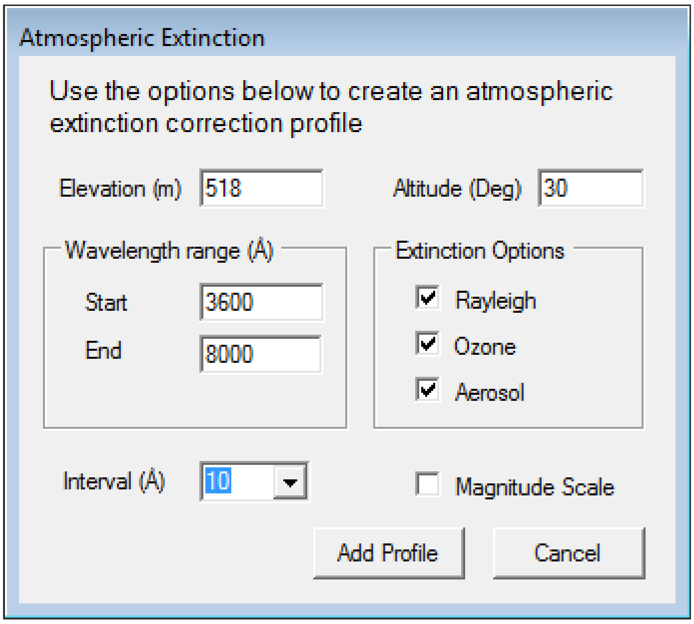
- Close – a button to close the form.

2.20 Atmospheric Extinction Screen

This screen is available from the Tools -> Atmospheric Extinction menu and is used to model atmospheric extinction and output an extinction profile based on chosen parameters such as site altitude, line of sight angle, wavelength range and interval etc. The profile can then be subsequently applied (via division operation) to target spectra to correct for atmospheric extinction.

This function does not correct for telluric absorption lines, see the H20 screen 2.24.

The calculations are based on a Fortran function provided to me by Tony Mallama (where the extinction formulas originated from a Christian Buil spreadsheet).



Atmospheric Extinction

Use the options below to create an atmospheric extinction correction profile

Elevation (m) 518

Altitude (Deg) 30

Wavelength range (Å)

Start 3600

End 8000

Extinction Options

☑ Rayleigh

☑ Ozone

☑ Aerosol

Interval (Å) 10

☐ Magnitude Scale

The following options are available

Elevation – enter the site elevation (metres above sea level)

Altitude – enter the line of sight altitude angle (degrees). The default 90 degrees value corresponds to the zenith.

Wavelength Range – enter the start and end wavelength ranges (in unit specified within BASS). The default range is 3000 to 10000 Angstroms.

Interval – select the sampling interval (in unit specified within BASS). The larger the number selected the fewer points in the profile. The default is 10 Angstroms (=1nm). For comparison, the Pickles reference spectra use a 5 Angstrom interval.

Extinction Options – choose one or more sources of extinction from the three options provided. All three are selected by default.

Magnitude scale – Tick the checkbox to create a profile in magnitude units. The default 'off' position will output as flux, which is the option to use for operations within BASS. The magnitude scale is useful for photometric purposes (outside of BASS)

Add Profile – Click the button to add a new extinction profile to the current project. You can remove an unwanted profile while keeping this screen open by selecting the image strip and clicking on remove profile.

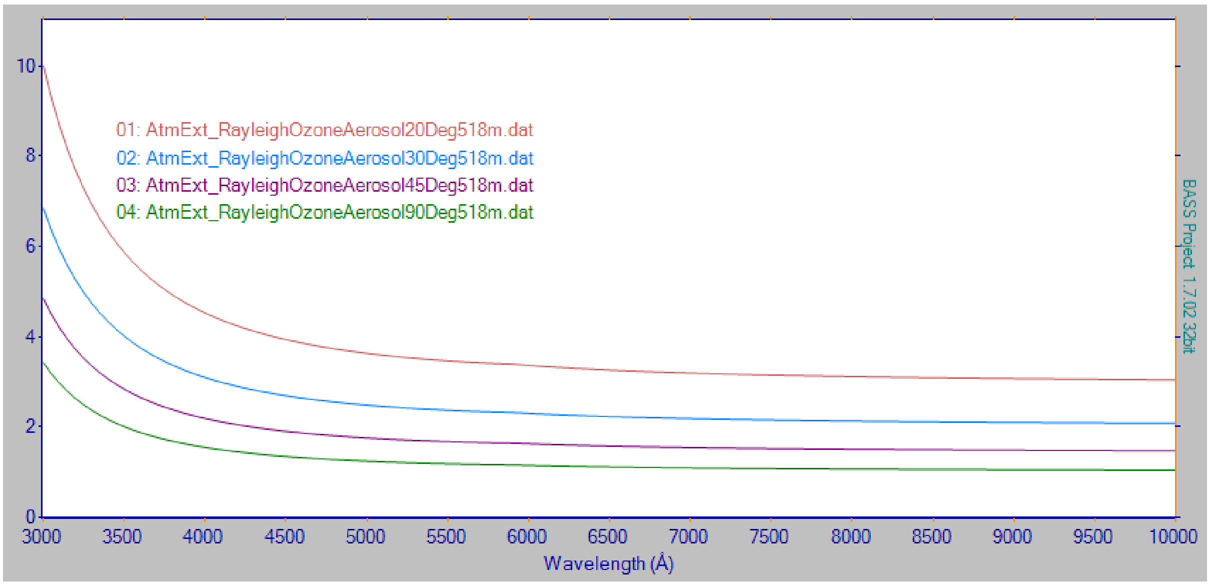
2.20.1 Using the extinction profiles

The extinction profile can applied to target profiles using a standard division operation.

Profiles are saved to disc as a DAT files using the standard options within BASS.

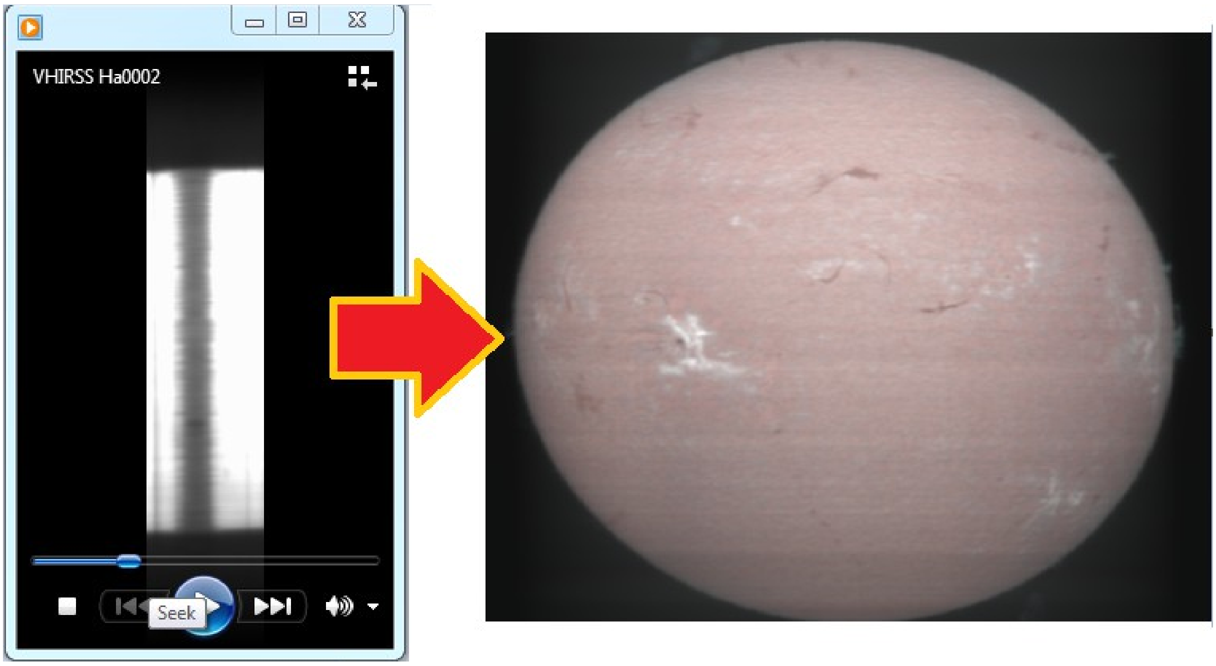
The default extinction profile caption is a long string that shows the parameters chosen, to help you distinguish between them. You can edit the captions using the Profile Properties screen.

Each profile added is automatically scaled to fit the chart area. Modify the scaling on Y axis Tab of profile properties if you wish to compare extinction profiles on same scale. The shot below shows extinction for 20, 30, 45 and 90 degree altitudes.



2.21 Reconstruct Image screen

This screen will scan spectra from an AVI file or a set of images in order to construct an image filtered by one or more wavelengths.



Thanks to Fulvio Mete for providing the data to construct the Solar image above.

The functionality is described in the BASS Spectroheliograms and image reconstruction from spectra PDF document available at the link below:

https://www.dropbox.com/s/oaet87fs3110ub3/Spectroheliograms%20and%20image%20reconstruction%20from%20spectra.odt?dl=0

2.22 Doppler Shift screen

The Doppler Shift screen contains three tab headers.

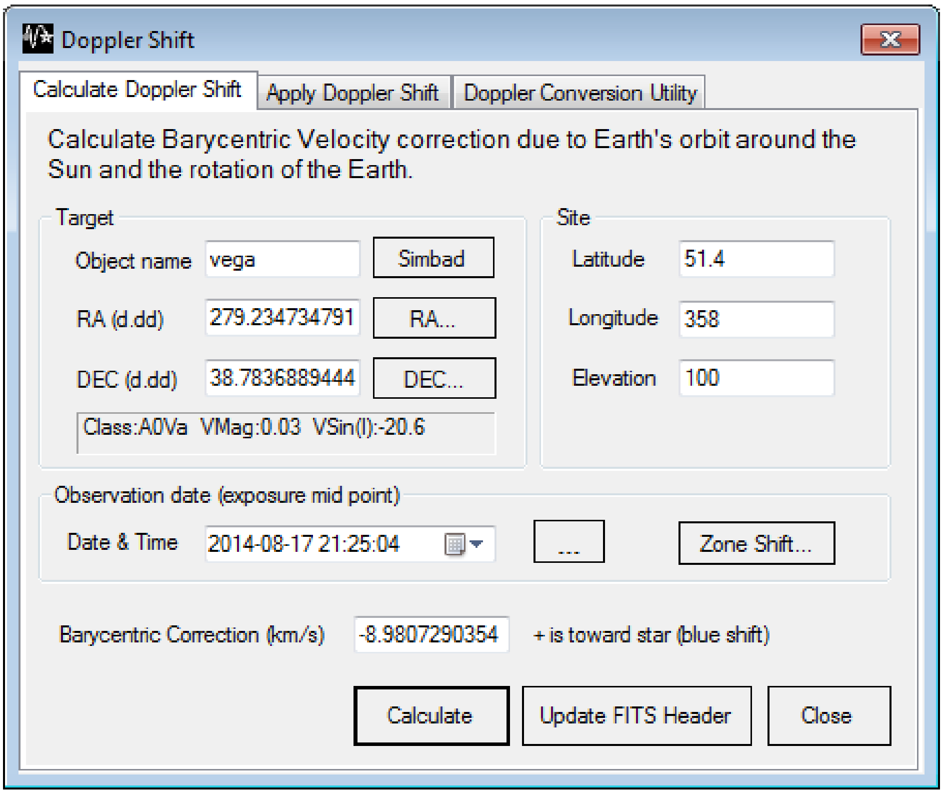
- Calculate Velocity Correction
- Apply Velocity Correction
- Doppler Utility

2.22.1 Calculate Velocity Correction tab

This tab performs the Doppler shift calculation and requires three sets of data organised into panels

- The Right Ascension and Declination the target object.
- The Latitude, Longitude and Elevation of the observing site location.
- The date and time of the mid-point of the observation (in universal time)

Values can be keyed in directly or pre populated from the FITS header if the screen is invoked from the BeSS Settings screen.



Calculate Barycentric Velocity correction due to Earth's orbit around the Sun and the rotation of the Earth.

Target

Object name: vega

RA (d.dd): 279.234734791

DEC (d.dd): 38.7836889444

Class:A0Va VMag:0.03 VSin(I):-20.6

Site

Latitude: 51.4

Longitude: 358

Elevation: 100

Observation date (exposure mid point)

Date & Time: 2014-08-17 21:25:04

Barycentric Correction (km/s): -8.9807290354 + is toward star (blue shift)

Target panel

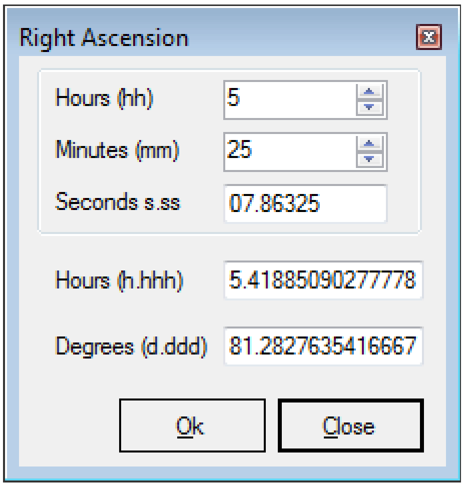
The RA and DEC are in decimal degree format and will be read in from the FITS header. These can also be keyed in or populated using the Simbad button to query an object name.

The RA button calls the Right Ascension popup to allow input and translation between the following formats

- hh mm ss.ss
- h.hh (decimal hours)
- d.dd (decimal degrees)

As you update one field the remainder are automatically converted.

Press Ok to pass the new value back to the calling screen



Hours (hh): 5

Minutes (mm): 25

Seconds s.ss: 07.86325

Hours (h.hhh): 5.41885090277778

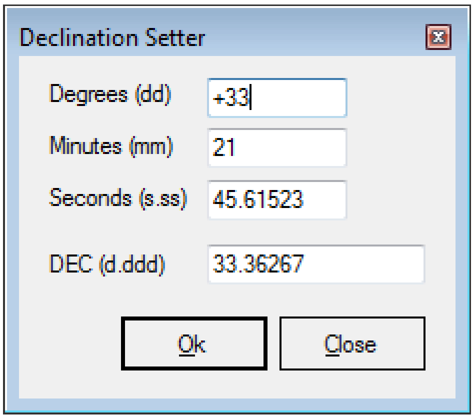
Degrees (d.ddd): 81.2827635416667

The DEC button calls the Declination popup to allow input and translation between the following formats

- dd mm ss.ss
- d.dd (decimal degrees)

As you update one field the remainder are automatically converted.

Press Ok to pass the new value back to the calling screen.


Declination Setter

Degrees (dd) +33
Minutes (mm) 21
Seconds (s.ss) 45.61523
DEC (d.ddd) 33.36267

Site Location panel

The latitude, longitude and elevation are read from the FITS header and saved when Update is pressed. Positive values are East.

Note that the BeSS Settings screen provides the ability to manage site locations

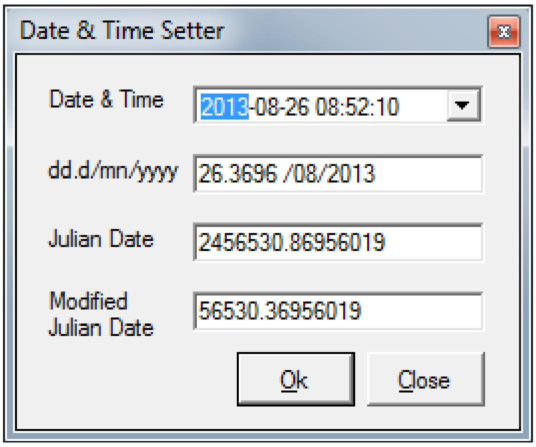
Observation Date - This is calculated as the 'mid point of exposure' when start date (DATE-OBS), end date (DATE-END) and/or exposure time (EXPTIME) fields are populated in the FITS header. The BeSS Settings screen provides better means to set these fields.

The "**…**" button opens the Date & Time Setter pop-up that allows input and conversion of dates in the following formats

- YYYY-mm-dd hh:mm:ss
- decimal day dd.dd/mm/yyyy
- Julian date /Modified Julian date

As you update one field the remainder are automatically converted.

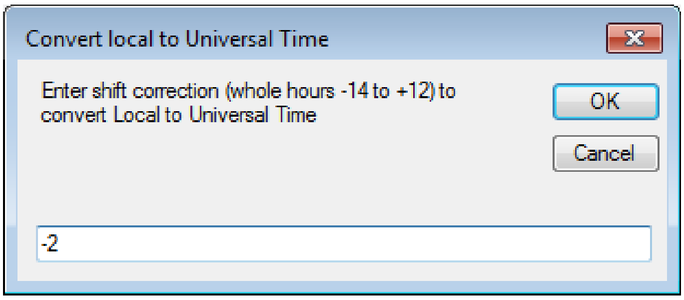
Press Ok to pass the new value back to the calling screen.


Date & Time Setter

Date & Time 2013-08-26 08:52:10
dd.d/mn/yyyy 26.3696 /08/2013
Julian Date 2456530.86956019
Modified Julian Date 56530.36956019

Use the Zone Shift button to convert local to Universal time,

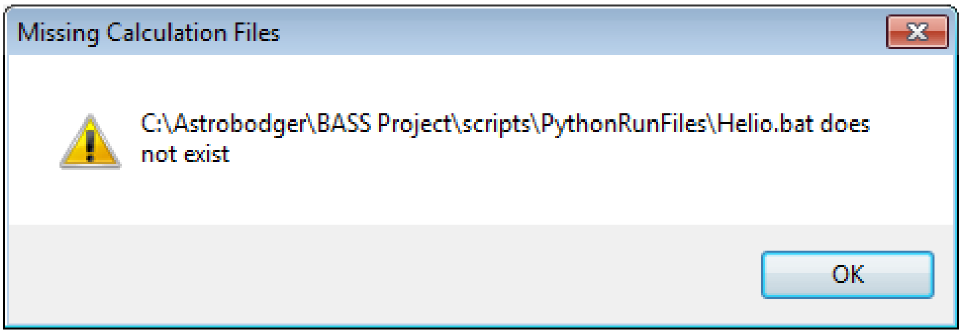
E.g. if you are +2 hours ahead you enter -2. This is less fiddly than editing the hours in the date box.


Convert local to Universal Time

Enter shift correction (whole hours -14 to +12) to convert Local to Universal Time

-2

Pressing the Calculate button will run the velocity calculation and populate the result into the box provided. However, if the following message is shown, check you have correctly installed the PythonRunFiles folder.



C:\Astrobodger\BASS Project\scripts\PythonRunFiles\Helio.bat does not exist

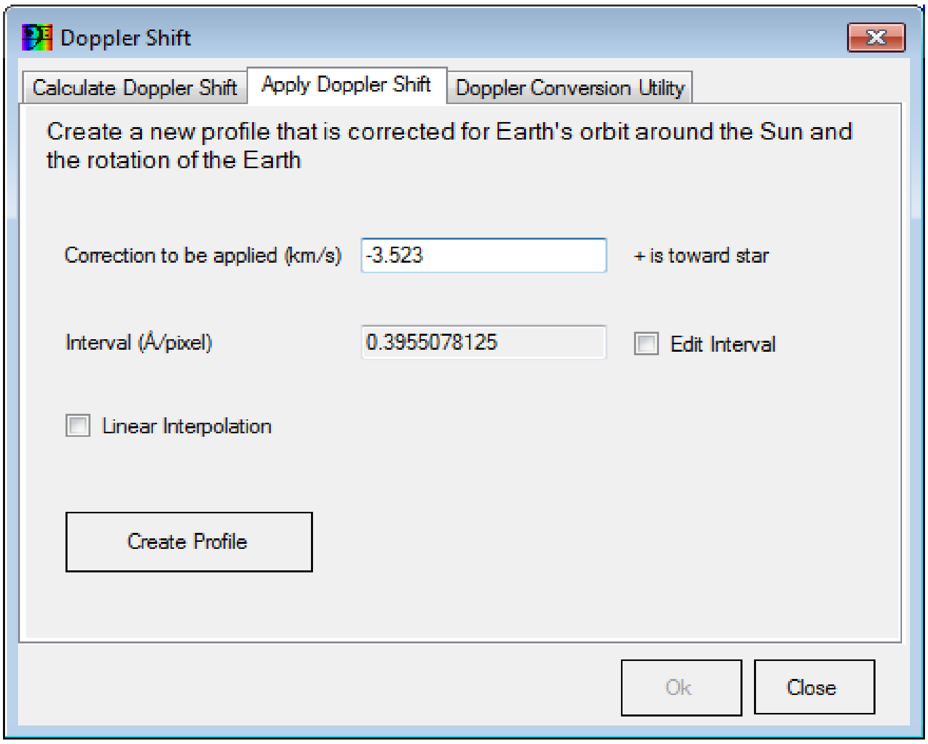
When ‘Update FITS header’ is pressed the following fields are updated:

- Calculated velocity (BSS_RQVH).
- Target object name, RA and DEC
- Site latitude, longitude & elevation. (Note: Negative West values are converted to be 0 to 360 degrees)

Important: If start date and exposure time fields are already populated in the FITS header, then changes made to the observation ‘mid-point’ date are NOT saved. The reasoning is concerned with issues ‘back fitting’ data when the calculated mid-point is changed. Use the BeSS Settings screen to manage these fields.

2.22.2 Apply Velocity Correction tab

This screen will create a new profile that applies the Doppler shift to the current profile. The correction will be of opposite sign to the measured velocity. For example if the target velocity is blue shifted by +16 km/s, then the correction will apply a red shift of -16 km/s to return the spectrum to the ‘at rest’ state.



Create a new profile that is corrected for Earth's orbit around the Sun and the rotation of the Earth

Correction to be applied (km/s) -3.523 + is toward star

Interval (Å/pixel) 0.3955078125 ☐ Edit Interval

☐ Linear Interpolation

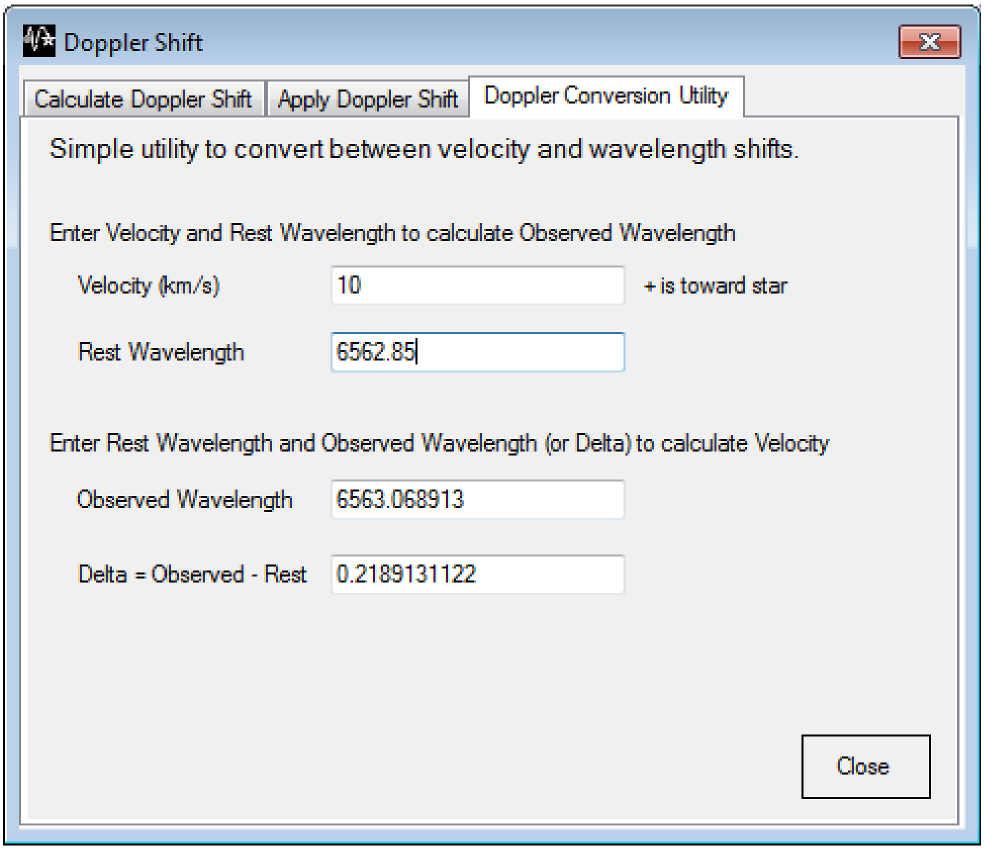
The creation of the new profile usually requires resampling. This uses the interpolation and interval settings:

- Interval - The default Interval value is based on the lowest interval of the source profile. This can be edited if the checkbox is ticked
- Linear interpolation – this checkbox prevents interpolation using the default cubic spline method.

The applied Doppler correction is saved to the FITS header (in the BSS_VHEL field). Linear FITS calibration parameters are also calculated and saved where the source profile used non-linear calibration.

2.22.3 Doppler Utility tab

This tab allows various conversions between velocity and wavelength to be easily carried out. It does not save any values to the FITS header or modify any profiles.



Simple utility to convert between velocity and wavelength shifts.

Enter Velocity and Rest Wavelength to calculate Observed Wavelength

Velocity (km/s): 10 + is toward star

Rest Wavelength: 6562.85

Enter Rest Wavelength and Observed Wavelength (or Delta) to calculate Velocity

Observed Wavelength: 6563.068913

Delta = Observed - Rest: 0.2189131122

Use any Wavelength unit of your choice, but be consistent.

The functionality can be explained with some examples below:

Q1: Find the Hydrogen alpha line wavelength when blue shifted by 10 km/s

- Enter Hydrogen alpha Rest Wavelength as 6562.82 (Angstroms)
- Enter Velocity of 10 km/s
- As Rest Wavelength and Velocity are edited, the Observed wavelength and Delta are automatically calculated.

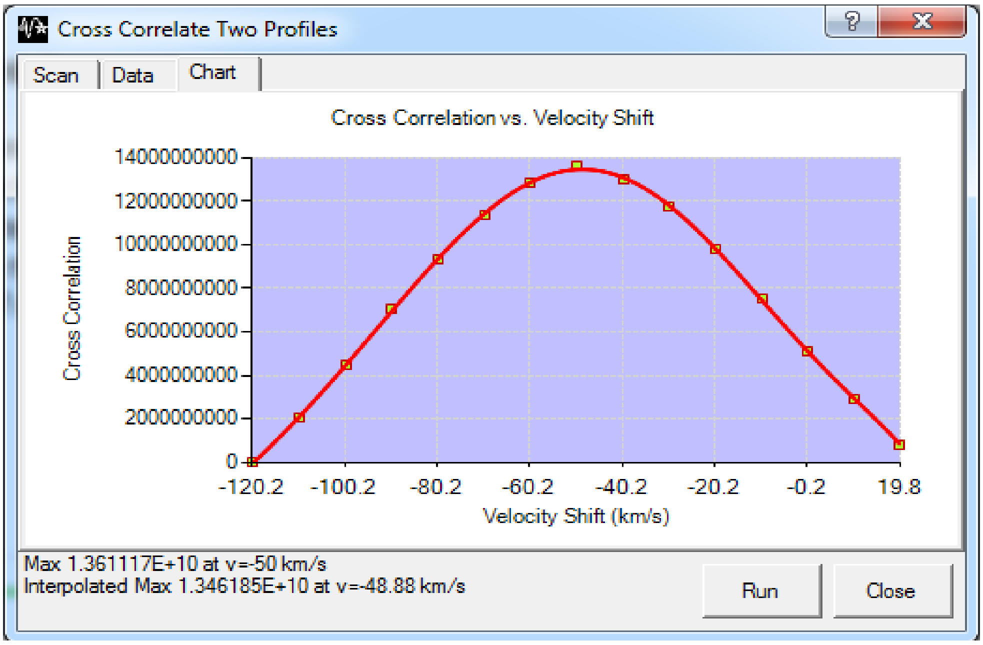
Q2: Find the velocity for a wavelength change of 0.15 Angstroms of Hydrogen beta

- Enter Hydrogen beta Rest Wavelength as 4861 (Angstroms)
- Enter Delta =0.15
- The Velocity is automatically calculated when Rest Wavelength, Delta or Observed wavelength are edited.

2.23 Cross Correlation Screen

This tool is accessed from the Tools menu. It performs a one dimensional cross correlation of two profiles in order to determine the Doppler shift between them. This provides an alternative to calculating the Doppler shift by measuring individual features or dips. Cross-correlation is a measure of similarity of two profiles as a function of the velocity displacement of one relative to the other.

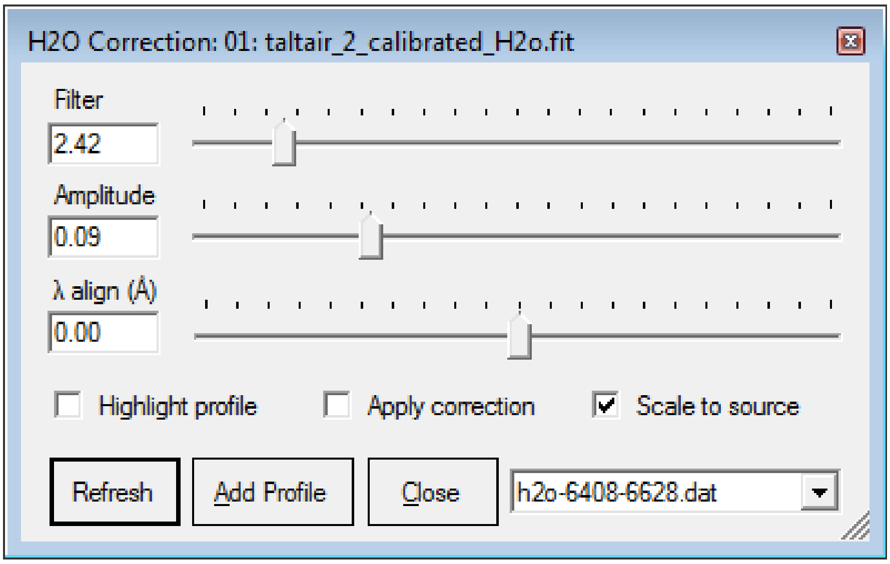
Please refer to the BASS Cross Correlation document for a detailed explanation of the process steps involved. https://www.dropbox.com/s/sbxy9kr3txdz6d3/BASS%20Cross%20Correlation.pdf?dl=0



Max 1.361117E+10 at v=-50 km/s
Interpolated Max 1.346185E+10 at v=-48.88 km/s

2.24 H2O Correction Screen

The screen is accessed via the Tools menu. The purpose is to remove features caused by telluric water lines



Filter: 2.42
Amplitude: 0.09
λ align (Å): 0.00
☐ Highlight profile ☐ Apply correction ☑ Scale to source
h2o-6408-6628.dat

2.24.1 Screen components

The screen components are:

- Filter – a textbox and slider that are used to set the amount of low pass filtering to be applied to the H2O reference profile lines. The goal is to adjust the resolution of the H2O reference lines to match those in the source profile.

- Amplitude – a textbox and slider that are used to match the intensity of the H2O reference lines to match those in the target.

- Lamda Align – a textbox and slider that are used to match x axis position of the target with the reference profile.

  The need for wavelength alignment could be calibration error. If it is only possible to align a limited part of the profile, then the target profile may need to be recalibrated, paying attention to the ‘calibration fit’ (e.g. quadratic, cubic).

- Highlight profile – a checkbox that increases the thickness of the result line to make it more prominent which can help with adjustments.

- Apply correction – a checkbox that show the result of the source profile divided by the H2O reference when ‘on’. When ticked ‘off,’ it shows the H2O profile.

- Scale to source – a checkbox (ticked ‘on’ by default) that sets the scaling of the result to be the same as the source profile. This normally best left ‘on’.

- Refresh a button to redraw the result. Especially after edit of Lamda, Amplitude or Filter text boxes.

- Add Profile a button to add the result profile to the project.

- Close a button to close the screen

- H2O Profile – a drop down list to select which H2O reference profile to use.

2.24.2 Prerequisites

- The source profile must be calibrated and be the top profile in the project.

- The source profile must have flux normalised to ‘1’ (otherwise the h2o correction might not be visible).

- H2O reference profiles need to be installed in the \reference\h2o folder under the BASS Project installation

- The source profile much match the wavelength ranges of one of the H2O reference profiles provided.

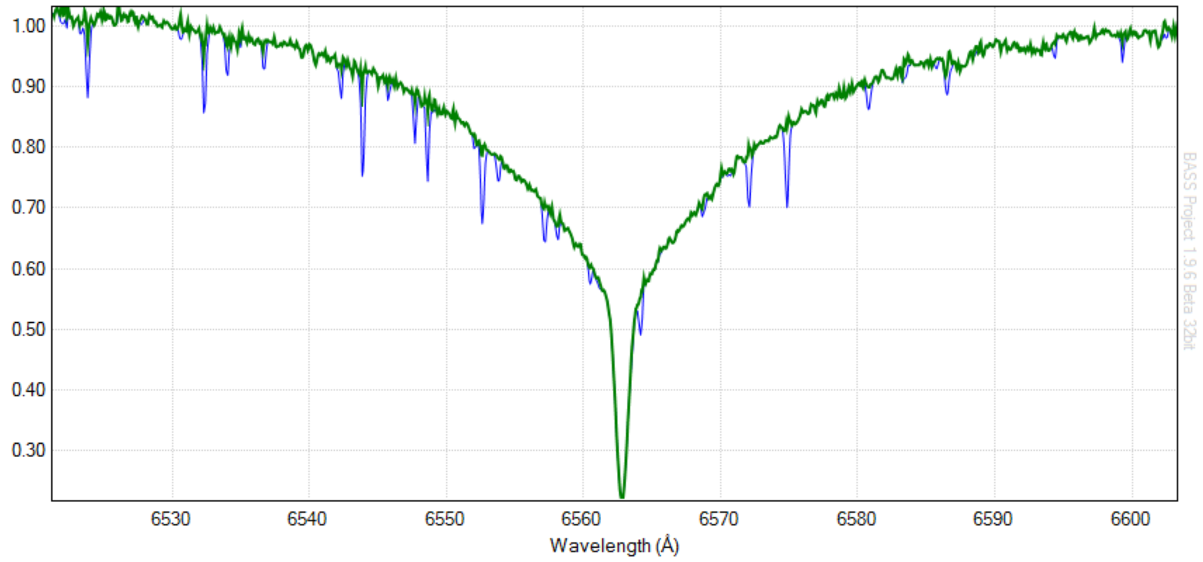
2.24.2.1 Applying correction

Click on the top source profile to be corrected before opening the H2O screen from the Tools menu.

Start off with the ‘Apply Correction’ checkbox turned ‘off’ to set the Filter, Amplitude and Align parameters in the ballpark, then switch ‘Apply Correction’ on and readjust to try to make the h2o lines disappear.

Adjustments of Filter, Amplitude and Align can be rather fiddly. Fine adjustments are possible using the arrow keys on the selected slider. The screen can be resized to increase the width of the sliders.

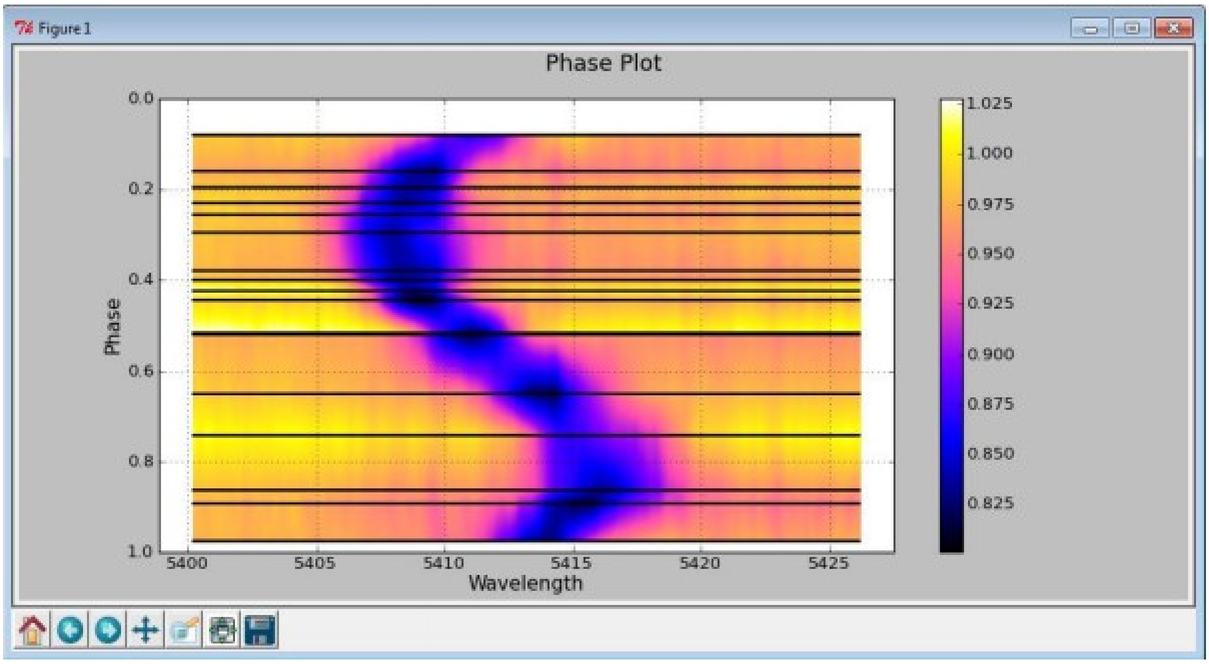
Values outside the range or unobtainable using the sliders, can be entered directly into the adjacent textboxes, (press Enter or click Refresh).



The green profile above shows the blue source profile after H2O correction

2.25 Phase Plot Screen

A phase plot is a two dimensional surface representation with wavelength on x axis, phase (or time) on y axis. The colour denotes flux.



You must have the PythonFileFiles folder installed to run Phase Plot options.

For clarification – you don't need to install the Python language yourself. The zip file contains compiled executable applications and includes dependencies.

Functionality is described in the short tutorial available at the link below:BASS Project Phase Plotting v1.9.4

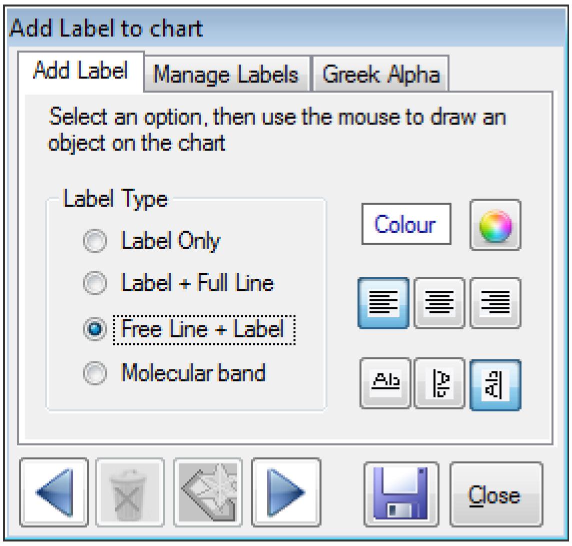
2.26 Labels Screen

The Labels screen is invoked from a toolbar icon , the main Tools -> Labels menu or the context sensitive chart menu

When the screen is opened, the chart will be in "Add Label mode" with the status bar text shown in green.

The Labels screen provides options to set display colour, text properties and how a line should be displayed. The label itself is created by using the mouse to draw a rectangle on the chart, positioned at the feature to be displayed.

Note that the font used for labels can be set in the Advanced tab of the Project Settings screen.



Select an option, then use the mouse to draw an object on the chart

Label Type
- ○ Label Only
- ○ Label + Full Line
- ● Free Line + Label
- ○ Molecular band

Tab Headers –Select option for:

- Add Label - Set label type and properties of the new label (changes to "Edit Label" if an existing label is being modified).
- Manage Labels – This displays existing labels in a list. This allows any label to be modified or removed.
- Greek Alpha – allows letters from the Greek alphabet to be copied/pasted into label text.

Label Annotation Type – this panel allows a choice of label types:

- Label Only – displays a text block (without any lines) at the location selected using the mouse on the chart.

- Full Line & label – as Label Only, but includes a full height vertical line at the wavelength position.

- Scaled Element line – draws a Gaussian curve or line at the element position. A line is drawn when the Sigma value in the Elements tab of Chart Settings has a zero value. A non-zero value plots a Gaussian curve with the specified sigma (standard deviation).

- Free Line & Label – draws a line from the start to the end position where a text block is positioned. Unlike Label & Full Line, this line can be any length or angle.

- Molecular Band – draws a graduated icon at the selected location. The graduation can be left to right or reversed depending on the text justification.

Colour picker – allows selection of the text display colour (and line where applicable)

Text Justification – these options allow a choice of how text is aligned (justified)
- Left – the text is left justified and the text block is positioned to the left of a line (if a line exists).
- Centre - the text is centrally justified and the text block is centred on the line (if a line exists).
- Right – the text is right justified and the text block is positioned to the right of a line (if a line exists).

Text Orientation – these options allow a choice of how text is orientated
- Horizontal – text is horizontal
- Vertical Clockwise – text is rotated 90 degree clockwise
- Vertical Anti-clockwise – text is rotated 90 degree anti-clockwise

Wavelength – this textbox is provided to key in X-axis position more accurately than using the mouse.

Intensity - this textbox is provided to set the Y-axis position as a percentage of the chart height (0 to 100). For Scaled Element Lines, this intensity value is contained in the element data file and often exceeds 100.

Element - this text box is provided to optionally specify an element name or symbol. Note that the height of scaled element lines is relative to those of the same element.

Line Style – this drop down list provides a choice of line styles is provided (e.g. solid, dashed etc.)

Arrow Head – this checkbox shows an arrow head cap that is used to point at a profile feature For Free Line & Label annotations only.

Previous icon– this button navigates to the previous label, if applicable. This sets the screen in 'edit' mode allowing changes to the current label to be made.

Remove icon – this button removes the selected label

Add icon – this button sets the screen in 'add' mode ready for a new label to be added.

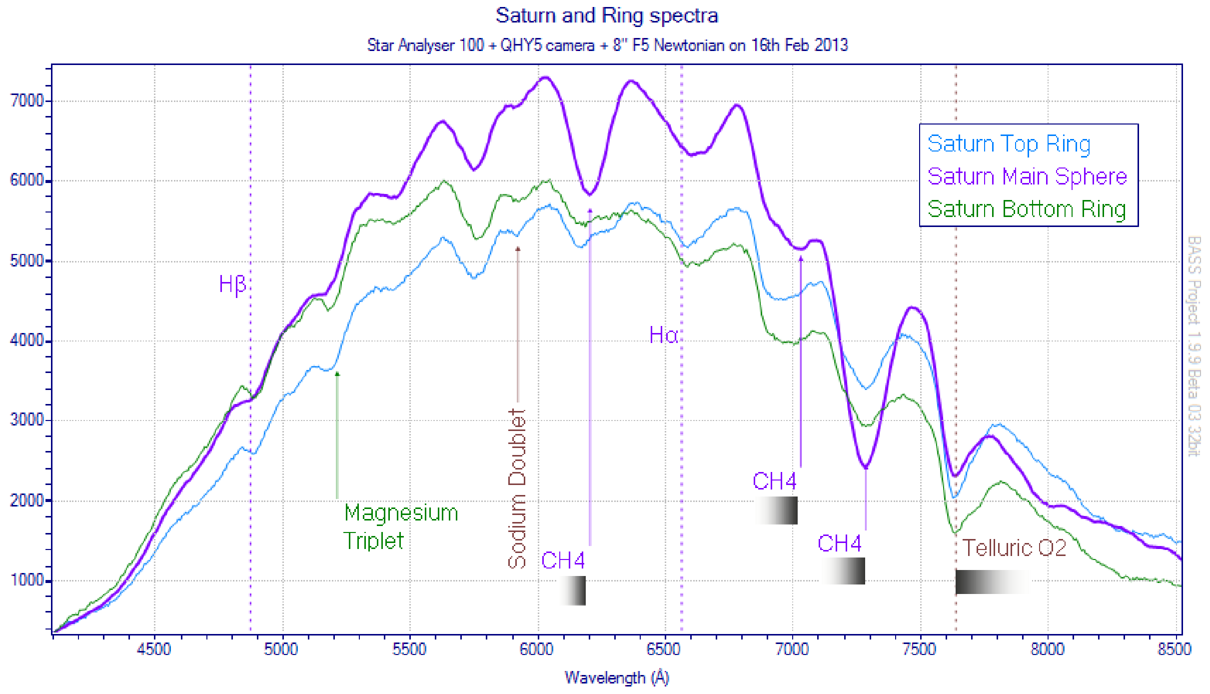
<u>Next icon</u> – this button navigates to the next label, if applicable. This sets the screen in ‘edit’ mode allowing changes to the current label to be made.

<u>Save icon</u> – this button updates the chart with the label and remains in ‘edit’ mode allowing the label just saved to be adjusted/edited.

Don’t forget to save the project after you have come out of the labels screen.

<u>Close</u> – this button closes the form

The screen shot below shows some annotation examples.



2.26.1 Adding a label

The screen can be in one of two modes; ‘add’ or ‘edit’ as displayed on the screen caption. Add mode is the default, otherwise press the Add button.

- Select the Label Annotation Type.

- Click on the chart to select the position. The label textbox and/or line (depending on line type) will be positioned at the point where the mouse is used to draw a rectangle or line. This can be the position of the spectral feature line to be annotated.

- The text area will, by default, be populated with the wavelength (or pixel if not calibrated) at the starting label position.

- Overwrite this with your own text. Press the Enter key to format the text with carriage returns (multiple lines) if required.

- Press the Save button to add the label to the chart.
- Don’t forget to save the project as labels belong to a project.

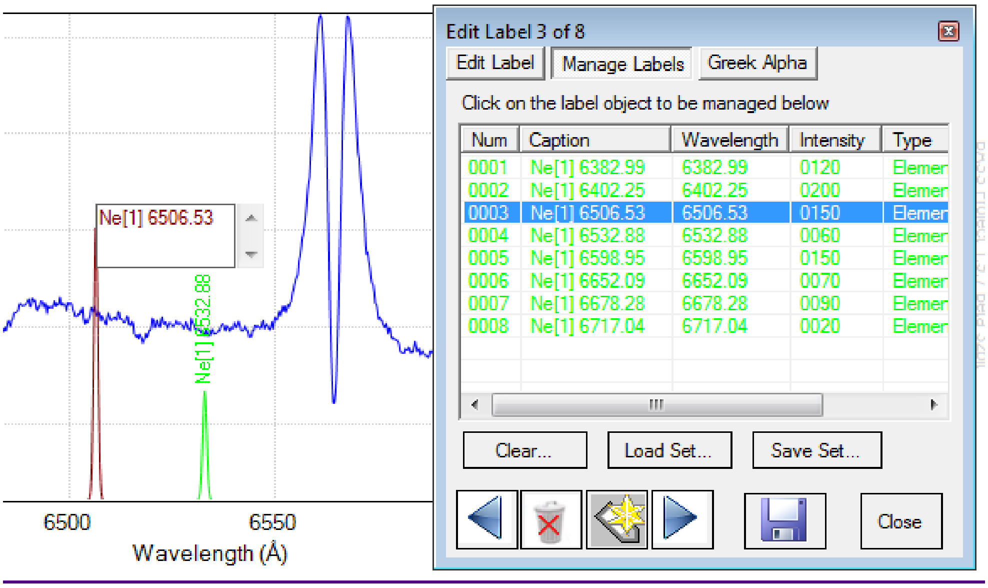
Once saved, the screen is in ‘Edit’ mode allowing you to make adjustments or changes. Press the Add button to add more labels.

2.26.2 Editing a label

Clicking on the Manage Labels tab header will display a list showing all the labels on the chart. This list and the navigation buttons provide the mechanism by which labels are selected for edit or removal.

Clicking on a row in the list of labels will put the Labels screen in ‘Edit’ mode. This is confirmed by the 1st tab text changing to “Edit Label’ and the screen caption “Label x of y” (where x is the index of the label being edited; y is the total number of labels on the chart).

Changing row will display an editable textbox at the text position, (or draw a border if it’s a molecular band). To change the position of the text, just reselect or draw the new position on the chart.

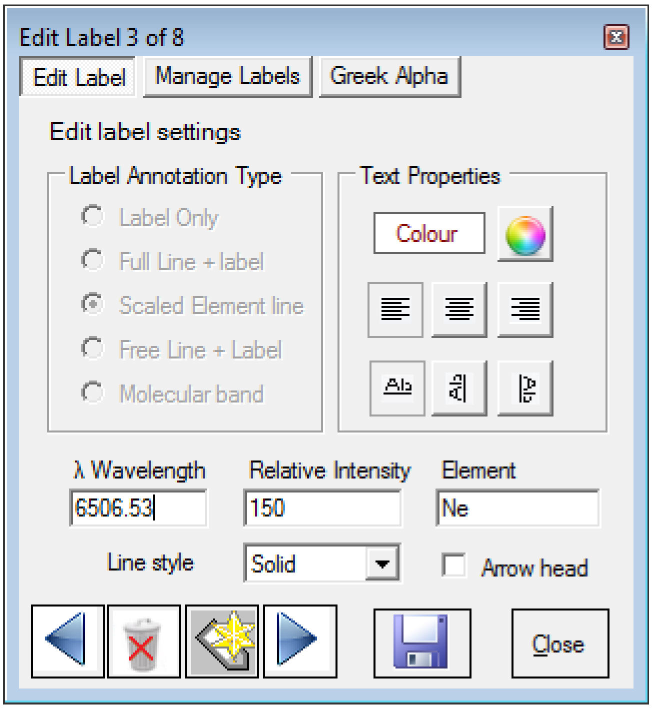


Click on the label object to be managed below

Num	Caption	Wavelength	Intensity	Type
0001	Ne[1] 6382.99	6382.99	0120	Elemer
0002	Ne[1] 6402.25	6402.25	0200	Elemer
0003	Ne[1] 6506.53	6506.53	0150	Elemer
0004	Ne[1] 6532.88	6532.88	0060	Elemer
0005	Ne[1] 6598.95	6598.95	0150	Elemer
0006	Ne[1] 6652.09	6652.09	0070	Elemer
0007	Ne[1] 6678.28	6678.28	0090	Elemer
0008	Ne[1] 6717.04	6717.04	0020	Elemer

Hint – you may find it easier to temporary save the label to move the screen out of the way if you wanted to make fine adjustments.

To change the colour, or other properties of the label, double click on the row or click on the Edit Label tab header.



Edit label settings

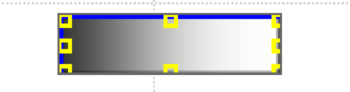
Label Annotation Type
○ Label Only
○ Full Line + label
● Scaled Element line
○ Free Line + Label
○ Molecular band

λ Wavelength: 6506.53
Relative Intensity: 150
Element: Ne
Line style: Solid
☐ Arrow head

> *Note: You cannot change the line type (e.g. you can't change a 'Label Only' to a 'Molecular Band'). Delete the old and add a new label.*

Press the Save button to save changes to the chart. Don't forget to also save the project if you want to keep changes for next time, or save as a Label Set if the annotations are not specific to a project.

A molecular icon can also be resized by having it selected and then clicking on it to show the yellow selection points on the sides and corners.



If you don't wish to save the label, click on another row, press the Add button or close the screen.

2.26.3 Removing a label

Navigate to the label to be removed then click on the 'Remove' button. Confirm removal when prompted.

Removing a label reverts the screen to 'Add' mode. To navigate to another label to be removed, either use the previous/next buttons or click on the row in the Manage Labels list.

Labels and annotations may be removed in bulk in the Manage Labels tab by first selecting one or more items in the grid and clicking the Delete button.

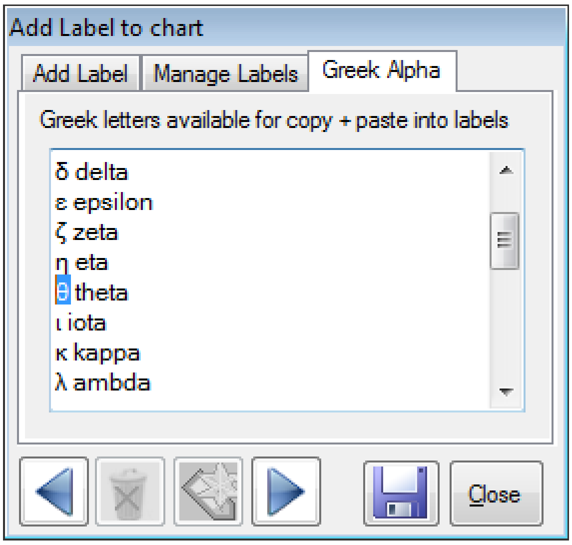
A Clear button is also provided in the Manage Labels tab to delete all labels and annotations.

2.26.3.1 Using Greek letters

Greek letters are widely used in astronomy to identify solar element lines and in the Bayer Designation of stars.

The third tab provides a multiline read only textbox allowing Greek alphabet characters to be copied for pasting elsewhere.

The list text is populated by the \Reference\GreekAlpha.txt file off the installation folder



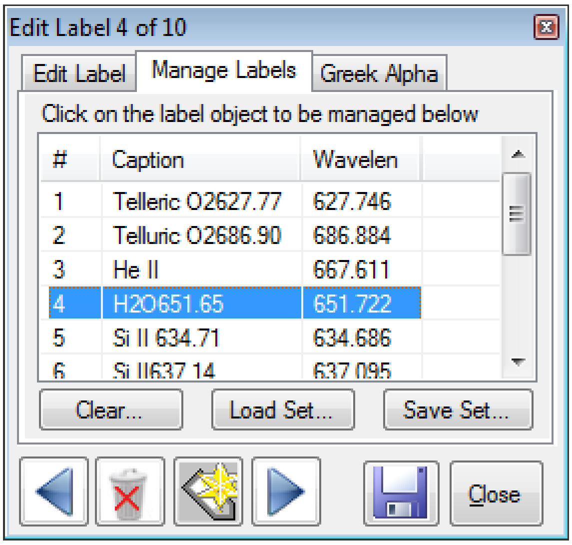
Greek letters available for copy + paste into labels

δ delta
ε epsilon
ζ zeta
η eta
θ theta
ι iota
κ kappa
λ ambda

2.26.4 Managing Label Sets

The Manage Labels tab of the Labels screen allows you to save a set of labels to be applied to other projects. This is an alternative to the functionality to save labels in a project. The main difference is that Label Sets are designed to be used across different projects where profiles can have different dispersions.

The position of label sets is based on wavelength so should be created based on a calibrated profile.



Click on the label object to be managed below

#	Caption	Wavelen
1	Telleric O2627.77	627.746
2	Telluric O2686.90	686.884
3	He II	667.611
4	H2O651.65	651.722
5	Si II 634.71	634.686
6	Si II637.14	637.095

This tab provides three buttons to manage sets of labels

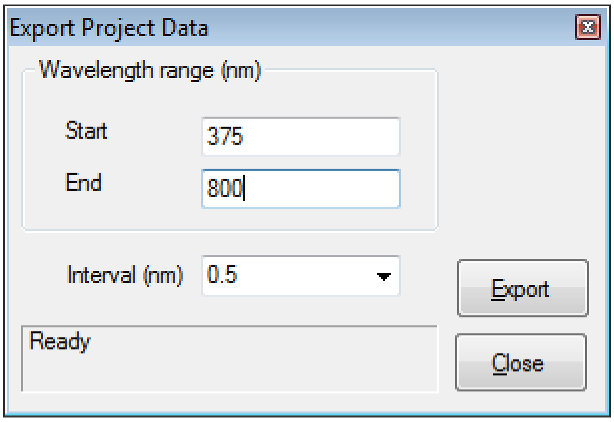
- Clear – this button will prompt to remove all label objects from the chart.
- Load Set – this will add label objects that have been previously saved to a *.lbl text file to the project Loading a set does NOT clear labels already loaded. This is deliberate as it allows you to merge sets of labels
- Save Set – this will save all chart label objects to a *.lbl text file

2.27 Export Project Data

The Export Project Data function is available from the toolbar icon or the Tools menu.

This function will export data for all the loaded profiles in a single data table using cubic spline interpolation to provide intensity values for common wavelengths.

The export requires the top profile to be calibrated.



Wavelength range (nm)

Start: 375

End: 800

Interval (nm): 0.5

Ready

Start Wavelength textbox – Enter the wavelength the export will start from. The Default value is wavelength of the first pixel from the top profile

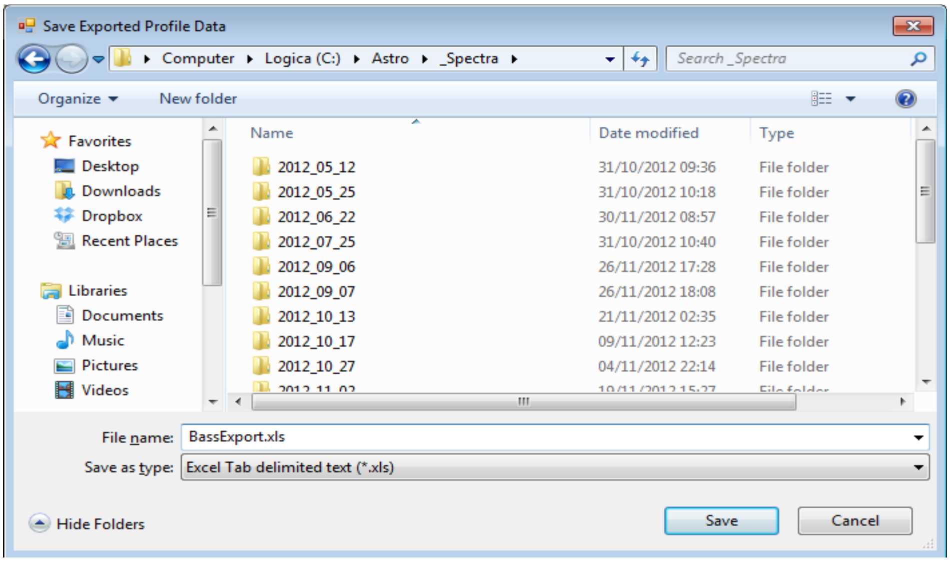
End Wavelength textbox – Enter the wavelength the export to. The Default value is wavelength of the last pixel from the top profile

Interval dropdown list – Enter or select the interval between successive rows exported. Lower values will increase the number of points exported (and take longer to process).

Export button – Starts the export

Close button – Close the form

Data is exported to a tab delimited text file selected from a Windows file save dialog.

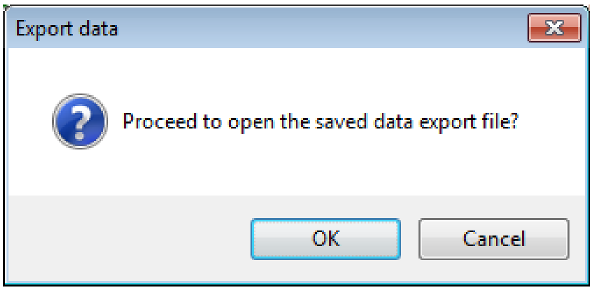


Name	Date modified	Type
2012_05_12	31/10/2012 09:36	File folder
2012_05_25	31/10/2012 10:18	File folder
2012_06_22	30/11/2012 08:57	File folder
2012_07_25	31/10/2012 10:40	File folder
2012_09_06	26/11/2012 17:28	File folder
2012_09_07	26/11/2012 18:08	File folder
2012_10_13	21/11/2012 02:35	File folder
2012_10_17	09/11/2012 12:23	File folder
2012_10_27	04/11/2012 22:14	File folder

File name: BassExport.xls

Save as type: Excel Tab delimited text (*.xls)

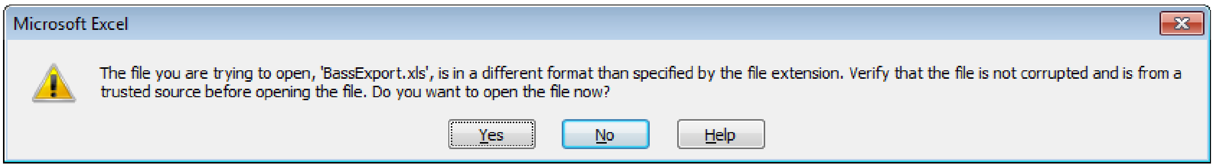
Once the data file has been saved, you are prompted with the option to launch the file.



Proceed to open the saved data export file?

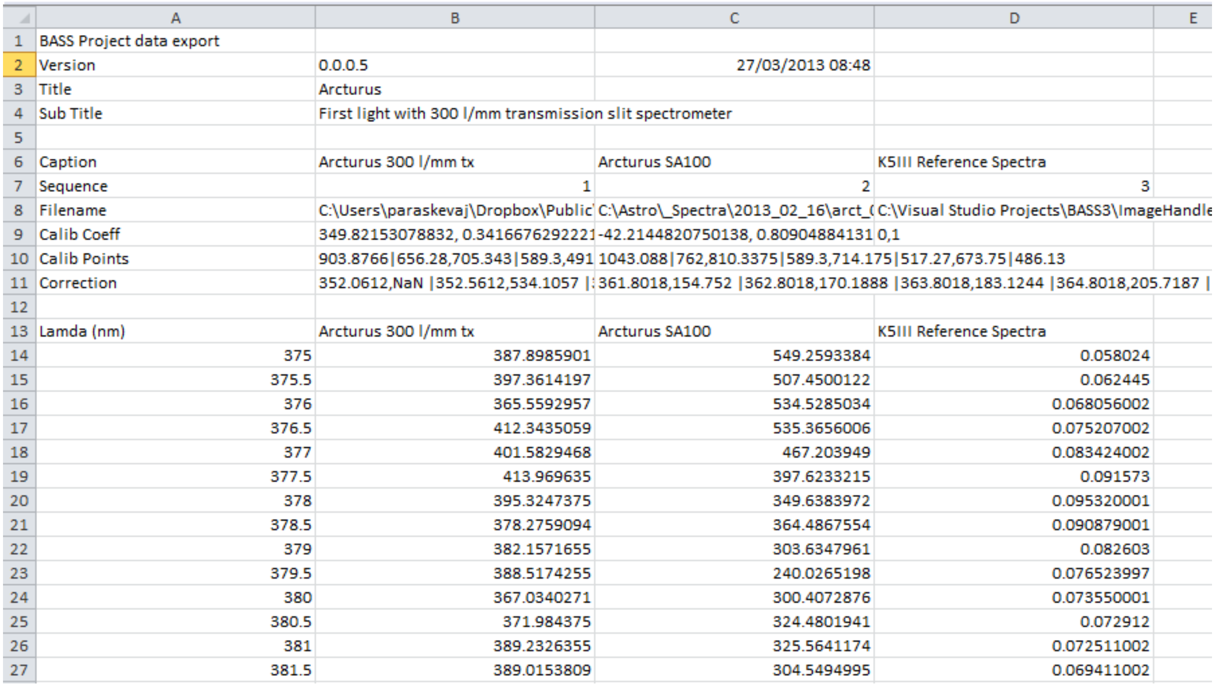
Launching the file will run whatever application is associated with the saved filename extension. This is typically Microsoft Excel, but should also work for OpenOffice, or other spreadsheet applications that support tab delimited files. Please allow time for the application to start, this can be 30 seconds or longer.

Select Yes if the spreadsheet application prompts to open the file.



The file you are trying to open, 'BassExport.xls', is in a different format than specified by the file extension. Verify that the file is not corrupted and is from a trusted source before opening the file. Do you want to open the file now?

An example of a project export is shown below. As the data is in unformatted tab delimited format, you may need to manually adjust the column widths to suit.



	A	B	C	D	E
1	BASS Project data export				
2	Version	0.0.0.5	27/03/2013 08:48		
3	Title	Arcturus			
4	Sub Title	First light with 300 l/mm transmission slit spectrometer			
5					
6	Caption	Arcturus 300 l/mm tx	Arcturus SA100	K5III Reference Spectra	
7	Sequence	1	2	3	
8	Filename	C:\Users\paraskevaj\Dropbox\Public	C:\Astro_Spectra\2013_02_16\arct_	C:\Visual Studio Projects\BASS3\ImageHandle	
9	Calib Coeff	349.82153078832, 0.3416676292221	-42.2144820750138, 0.80904884131	0,1	
10	Calib Points	903.8766|656.28,705.343|589.3,491	1043.088|762,810.3375|589.3,714.175|517.27,673.75|486.13		
11	Correction	352.0612,NaN |352.5612,534.1057 |	361.8018,154.752 |362.8018,170.1888 |363.8018,183.1244 |364.8018,205.7187 |		
12					
13	Lamda (nm)	Arcturus 300 l/mm tx	Arcturus SA100	K5III Reference Spectra	
14	375	387.8985901	549.2593384	0.058024	
15	375.5	397.3614197	507.4500122	0.062445	
16	376	365.5592957	534.5285034	0.068056002	
17	376.5	412.3435059	535.3656006	0.075207002	
18	377	401.5829468	467.203949	0.083424002	
19	377.5	413.969635	397.6233215	0.091573	
20	378	395.3247375	349.6383972	0.095320001	
21	378.5	378.2759094	364.4867554	0.090879001	
22	379	382.1571655	303.6347961	0.082603	
23	379.5	388.5174255	240.0265198	0.076523997	
24	380	367.0340271	300.4072876	0.073550001	
25	380.5	371.984375	324.4801941	0.072912	
26	381	389.2326355	325.5641174	0.072511002	
27	381.5	389.0153809	304.5494995	0.069411002	

2.28 BeSS Settings

A ‘BeSS Settings’ screen has been provided that allows the user to update the FITS header with the information required to allow a one dimensional FITS profile to be imported into BeSS standard compatible online databases such as BeSS, BAA and ARAS.

Although only experienced/advanced users would be the most likely to actually submit spectra to BeSS, this functionality and be used by the less advanced to store useful information into the FITS keyword fields.

Start by loading a calibrated one dimensional FITS image.

The BeSS screen is accessed from the Image menu or from the “BeSS” button on the General tab of the Profile Properties screen.

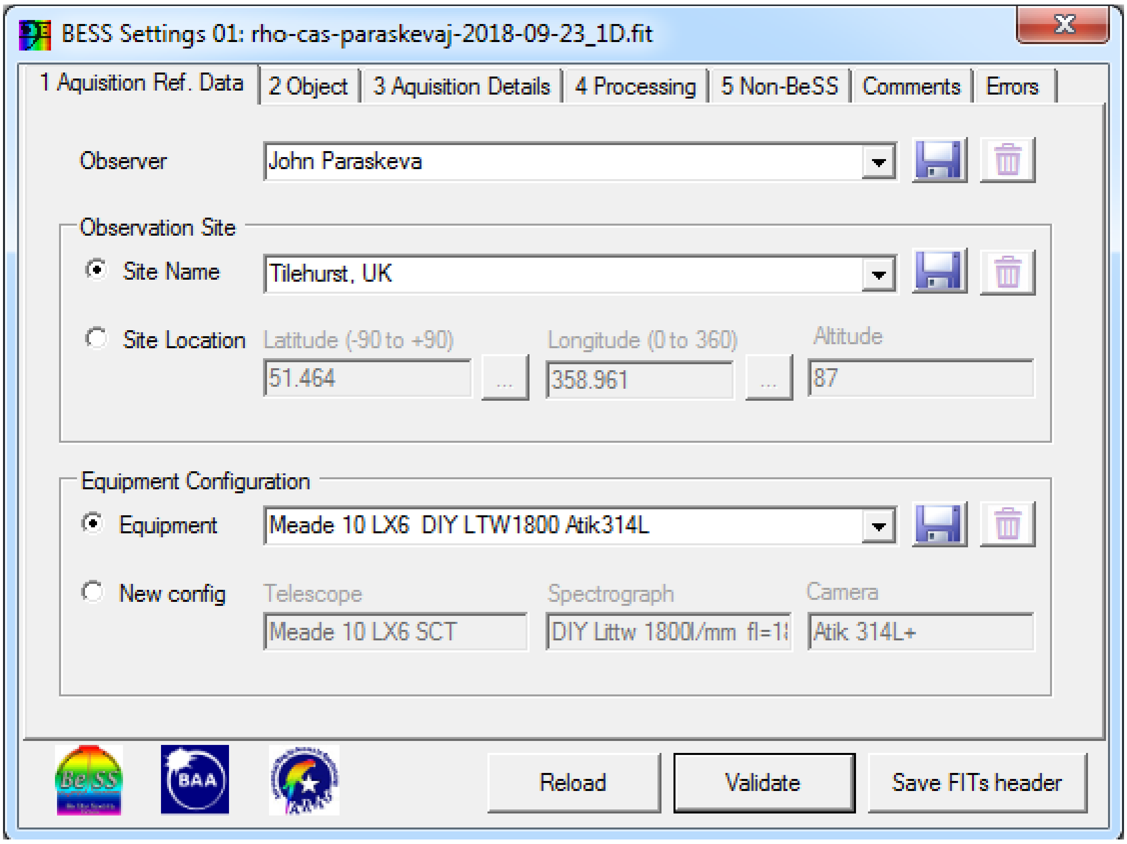
The screen provides multiple tabs organised to capture the required fields. There is also a tab provided to display error messages when the ‘Validate BeSS’ field is clicked.

Details regarding BeSS format and validation rules can be accessed from this link to the BeSS standard.

2.28.1 Acquisition Reference Data

The first tab collects Acquisition Reference Data.

The Observer, Site Name and Equipment fields provide Save and Delete icon buttons to manage locally stored values. These values would need to have been setup online in BeSS before files will be accepted for upload. The values are held in local text files under the <BassProject Install>\Reference folder.



BESS Settings 01: rho-cas-paraskevaj-2018-09-23_1D.fit

Observer: John Paraskeva

Observation Site

● Site Name: Tilehurst, UK

○ Site Location: Latitude (-90 to +90) 51.464; Longitude (0 to 360) 358.961; Altitude 87

Equipment Configuration

● Equipment: Meade 10 LX6 DIY LTW1800 Atik314L

○ New config: Telescope Meade 10 LX6 SCT; Spectrograph DIY Littw 1800l/mm fl=1; Camera Atik 314L+

The BeSS standard allows site and equipment to be identified either by a composite name or individual component fields.

Once a Site Name and its components are saved, selection using the Site Name drop down list will automatically populate Latitude, Longitude and Altitude.

Once an Equipment configuration and its components are saved, selection using the Equipment drop down list will automatically populate Telescope, Spectrograph and Camera.

The bottom section of the screen is common across all the tabs. This provides

BeSS Icon link – link to the BeSS spectral online web site. You can get details of the BeSS standard requirements for submission here.

BAA Icon link – link to the British Astronomical Association spectra web site

ARAS Icon link – link to the ARAS spectra database

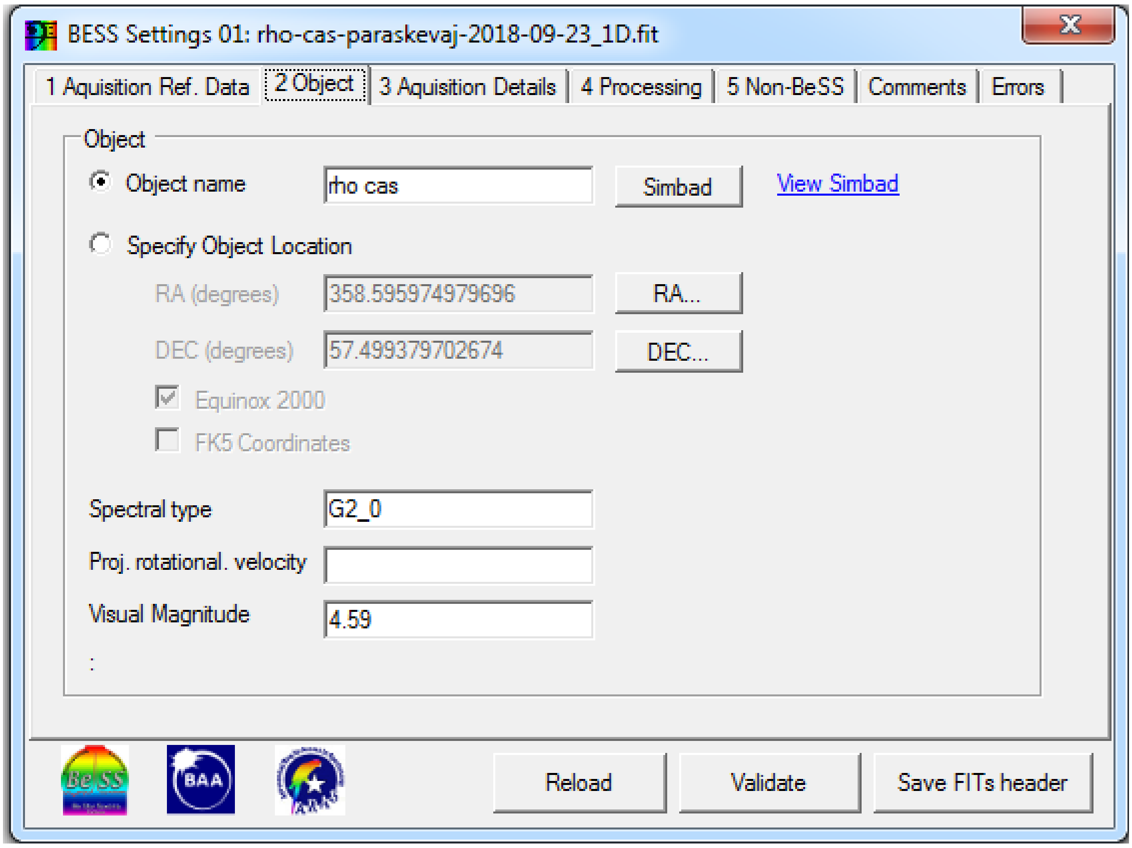
Reload – button to re-populate the fields with what is currently saved in the FITS header

Validate BeSS - button to validate fields are consistent with the basic BeSS rules. When an error is found, the screen switches to the Error tab which displays each error message and tells the user which tab header is relevant.
The validation is local, i.e. there is no real-time connection to the BeSS web site. See the BeSS website for details of the validation.

Save FITs header – button to save the contents of fields to the FITS header and prompt for the file to be saved. This does NOT validate against the BeSS rules.

2.28.2 Object tab

The Object tab allows the object to be specified.



BESS Settings 01: rho-cas-paraskevaj-2018-09-23_1D.fit

Object

● Object name: rho cas

○ Specify Object Location

RA (degrees): 358.595974979696

DEC (degrees): 57.499379702674

☑ Equinox 2000

☐ FK5 Coordinates

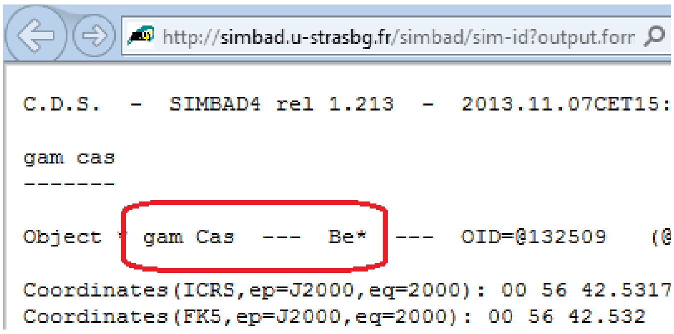
Spectral type: G2_0

Proj. rotational. velocity:

Visual Magnitude: 4.59

A Simbad button validates the object exists and populates many other fields using the Simbad online database (so requires an internet connection).

The View Simbad link loads the web page to validate the object exists and is of Be type for submission to BeSS. (Other on-line databases such as BAA or ARAS are not restricted to Be class objects).

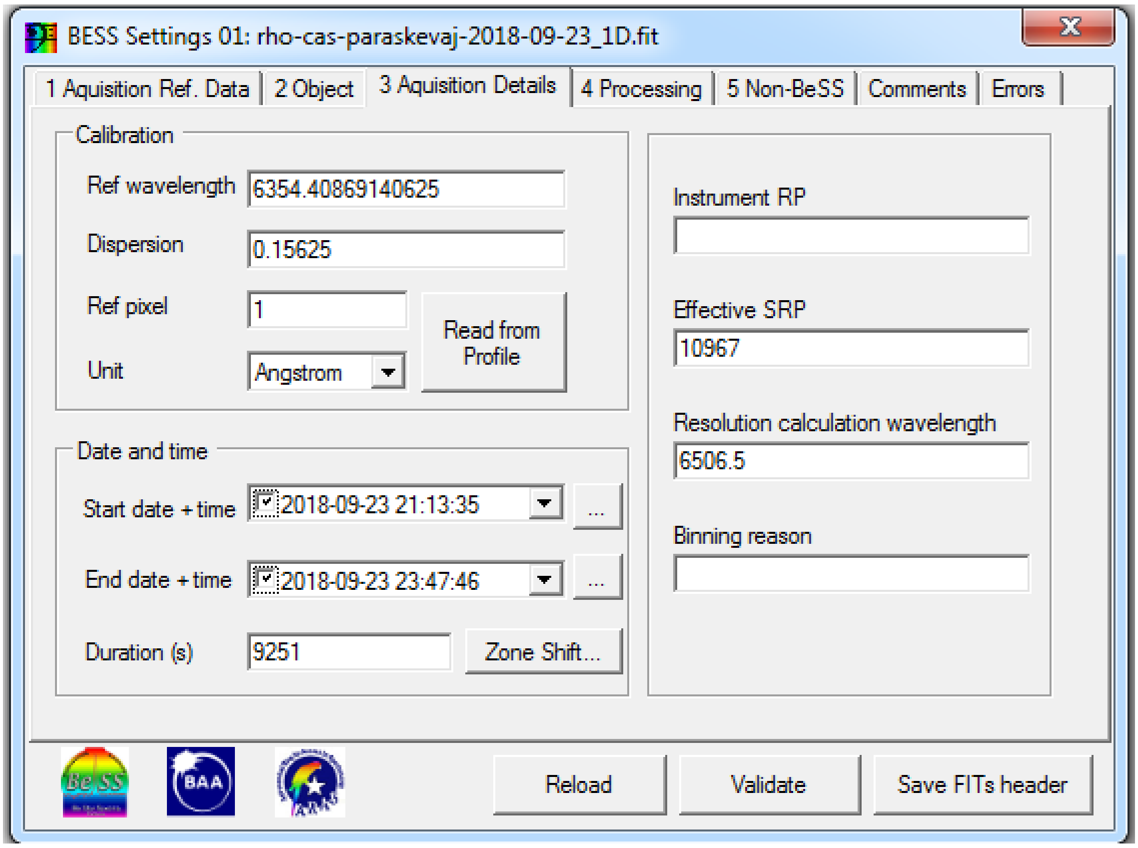


http://simbad.u-strasbg.fr/simbad/sim-id?output.forr

```
C.D.S.  -  SIMBAD4 rel 1.213  -  2013.11.07CET15:

gam cas
-------

Object   gam Cas  ---  Be*  ---  OID=@132509   (@

Coordinates(ICRS,ep=J2000,eq=2000): 00 56 42.5317
Coordinates(FK5,ep=J2000,eq=2000): 00 56 42.532
```

2.28.3 Acquisition Details tab

The Acquisition Details tab provides additional information such as calibration and when the object was captured.



Ref wavelength: 6354.40869140625

Dispersion: 0.15625

Ref pixel: 1

Unit: Angstrom

Start date + time: ☑ 2018-09-23 21:13:35

End date + time: ☑ 2018-09-23 23:47:46

Duration (s): 9251

Instrument RP:

Effective SRP: 10967

Resolution calculation wavelength: 6506.5

Binning reason:

The ‘Read from Profile’ button populates calibration data held in a BASS Profile into the FITS header fields required for BeSS.

You can choose to convert between Angstom or nm by selecting the unit before pressing the ‘Read from Profile’ button.

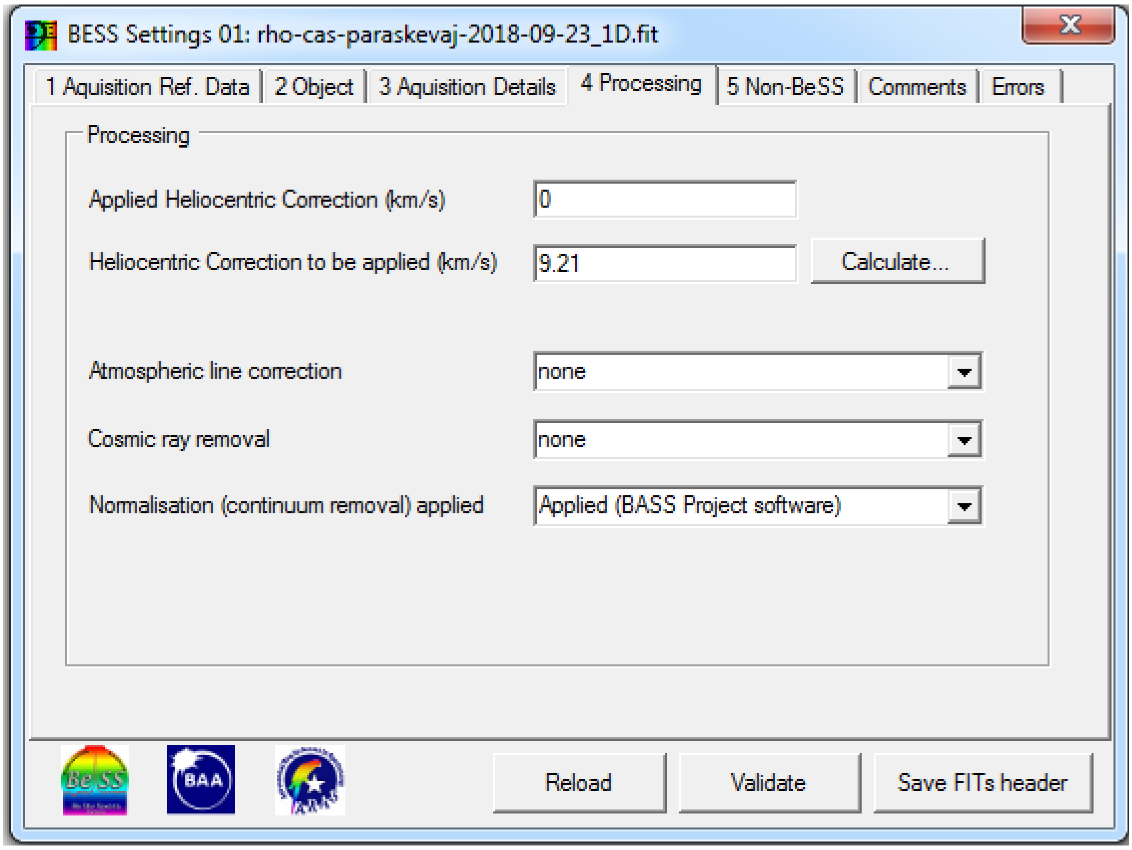
The FITS header keywords can only store a linear calibration. If a higher order calibration was performed, the average dispersion can be used, however it will be better to use Save to 1D function to linearise the profile by resampling.

The date + time panel allows start and end dates or one date and duration (seconds) to be specified. Date and time values can be adjusted using the date + time picker tools provided. (Dates are saved in the FITS file in yyyy-mm-ddTHH:MM:SS format.

2.28.4 Processing tab

The forth tab provides details of processing and what corrections have been applied.

The Calculate button calls the Calculate Doppler Shift functon to return a velocity correction.



Processing

Applied Heliocentric Correction (km/s): 0

Heliocentric Correction to be applied (km/s): 9.21

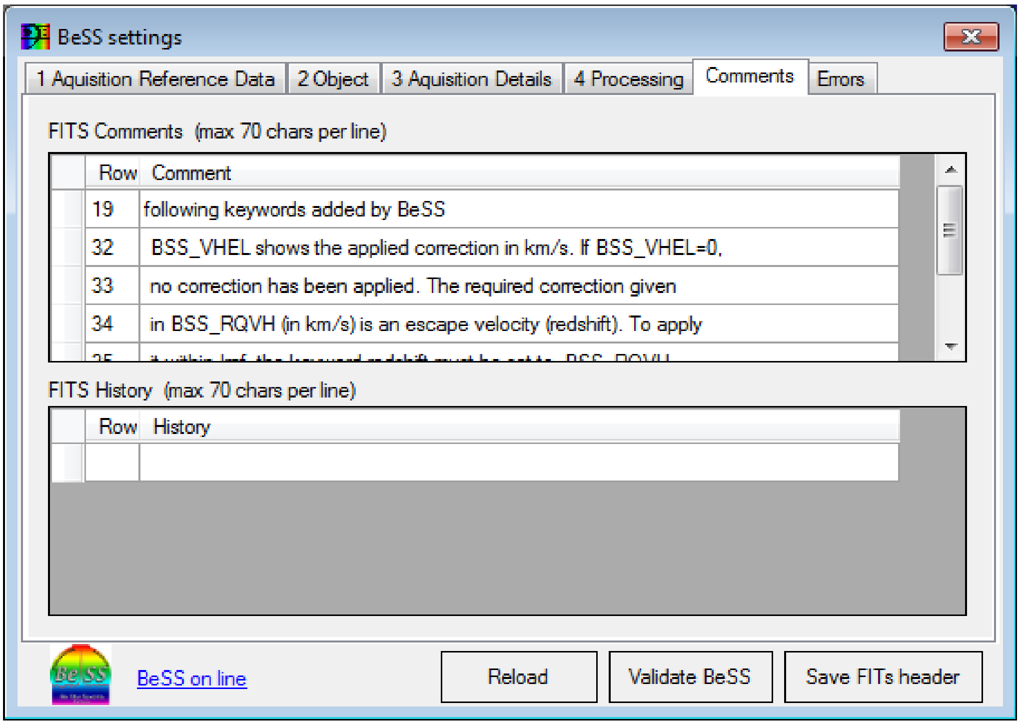
Atmospheric line correction: none

Cosmic ray removal: none

Normalisation (continuum removal) applied: Applied (BASS Project software)

2.28.5 Comments tab

The Comments tab allows management of the HISTORY and COMMENT keywords that can exist multiple times



FITS Comments (max 70 chars per line)

Row	Comment
19	following keywords added by BeSS
32	BSS_VHEL shows the applied correction in km/s. If BSS_VHEL=0,
33	no correction has been applied. The required correction given
34	in BSS_RQVH (in km/s) is an escape velocity (redshift). To apply

FITS History (max 70 chars per line)

Row	History

By default new entries are added near the end of the FITS Header. Press Reload after Save to see the allocated row number. The row number can also be edited to position at a particular point.

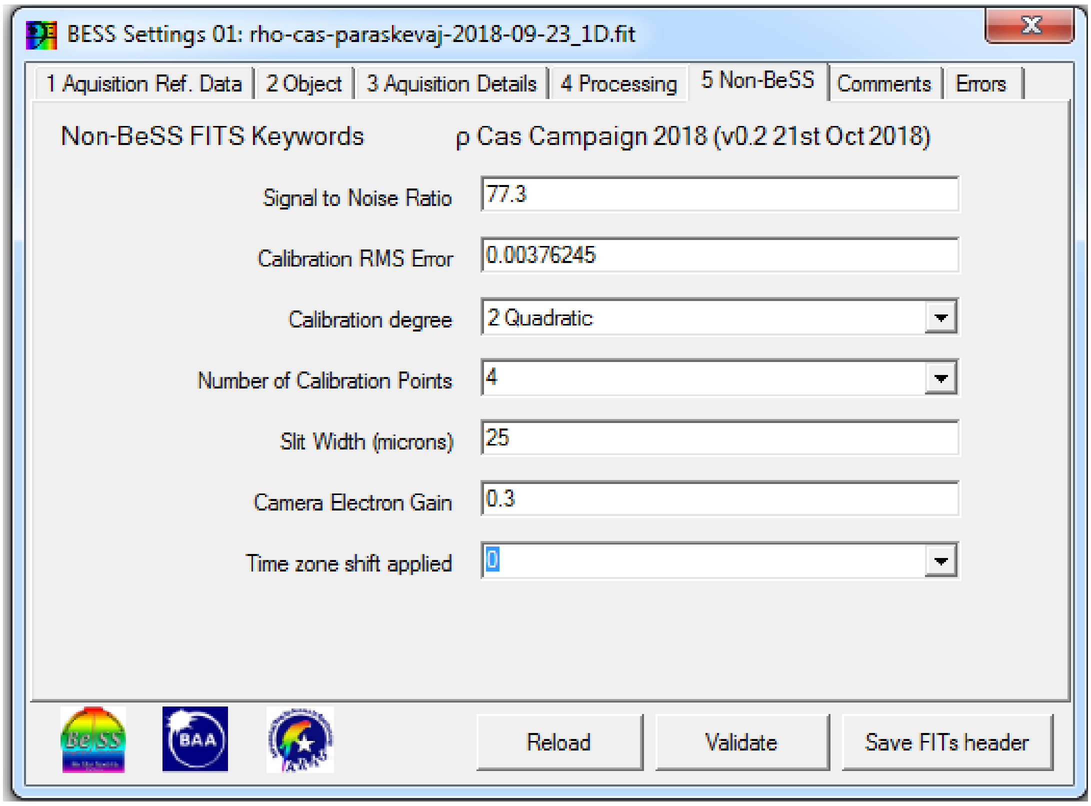
See the FITS Header screen to see the complete list of keywords and values in a raw sequential format.

2.28.6 Non-BeSS Keywords

Although the BeSS standard is the most widespread, it is targeted at Be class stars and may not contain all the keywords required for non-BeSS spectroscopic campaigns.

Additional FITS Keywords that are not required by the BeSS standard can be configured using a text based configuration file to be captured and/or validated in a 'tab 5' in the BeSS Settings screen.

The tab will only be visible if the 'NON_BESS_KEYWORDS.txt' configuration file exists in the BASS installation folder.



BESS Settings 01: rho-cas-paraskevaj-2018-09-23_1D.fit

Non-BeSS FITS Keywords   ρ Cas Campaign 2018 (v0.2 21st Oct 2018)

Signal to Noise Ratio: 77.3

Calibration RMS Error: 0.00376245

Calibration degree: 2 Quadratic

Number of Calibration Points: 4

Slit Width (microns): 25

Camera Electron Gain: 0.3

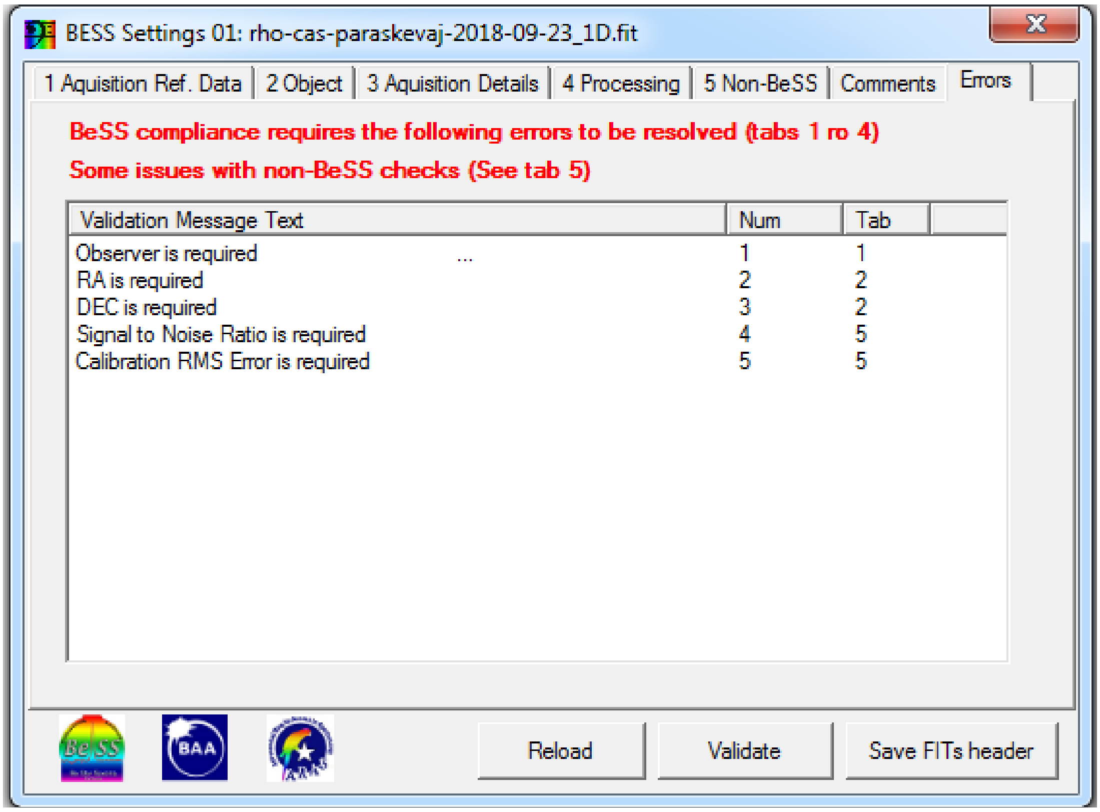
Time zone shift applied: 0

An example configuration file can be found from this link
https://www.dropbox.com/s/c57m6auwm2c5eal/NON_BESS_KEYWORDS.txt?dl=0

See the following document for more details
https://www.dropbox.com/s/no6jfgykcf2nfgt/BASS%20non-BeSS.pdf?dl=0

2.28.7 Errors tab

Shows warning error messages after the Validate BeSS button has been clicked



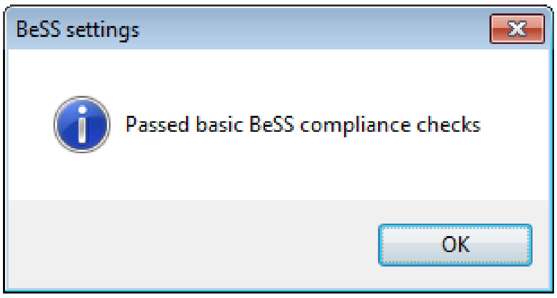
BESS Settings 01: rho-cas-paraskevaj-2018-09-23_1D.fit

BeSS compliance requires the following errors to be resolved (tabs 1 ro 4)

Some issues with non-BeSS checks (See tab 5)

Validation Message Text	Num	Tab
Observer is required ...	1	1
RA is required	2	2
DEC is required	3	2
Signal to Noise Ratio is required	4	5
Calibration RMS Error is required	5	5

If no errors are detected, a positive confirmation is provided.



BeSS settings

Passed basic BeSS compliance checks

The validation checks here are indicative and not as rigorous as BeSS on-line. (For example, there is no local validation that the object is a Be class star). The on-line BeSS file checking tool should be used before final submission to BeSS.

Note: The validation checks are for information only as the BeSS rules may not always be appropriate to what you are doing. For this reason, you can still save a profile and disregard validation messages.

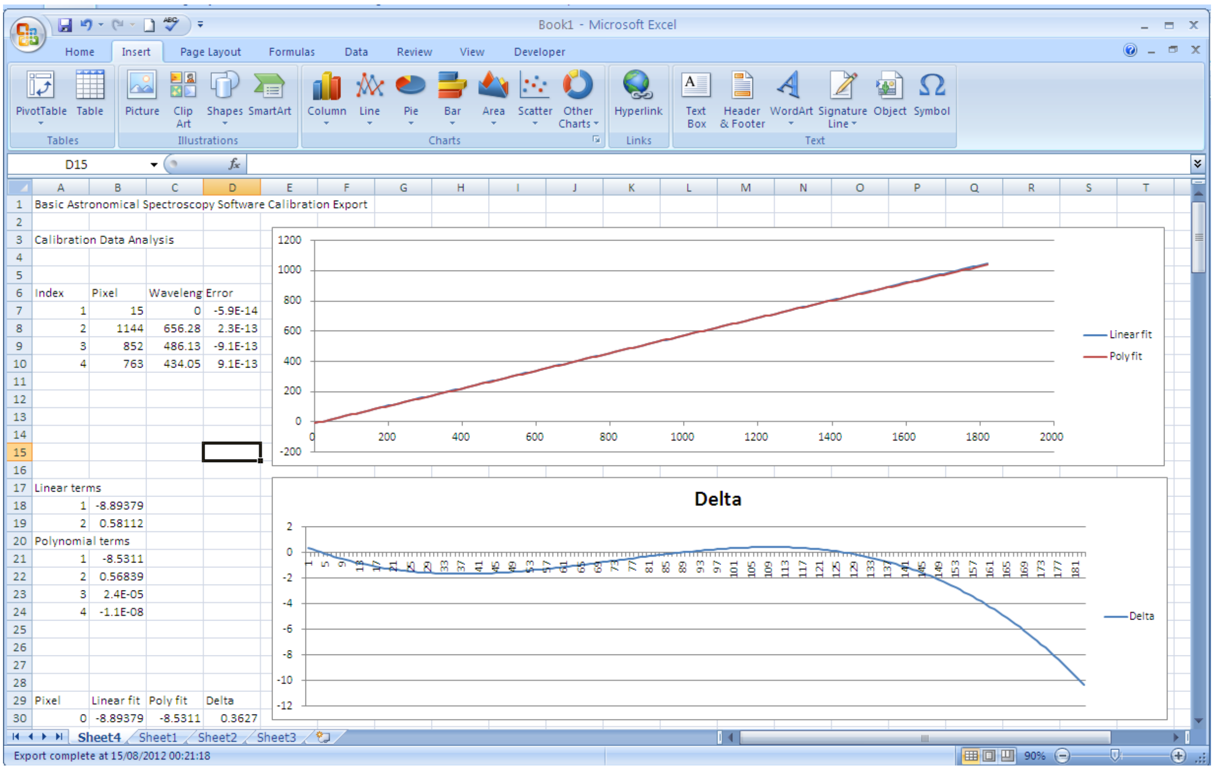
3 Appendix A – Calibration Export data file

The calibration export data file mainly aimed at advanced users who understand polynomial regression and can generate appropriate charts using the data exported. The main aim of this is to identify how good the fit will be and in particular if any mathematical inflection has occurred (i.e. if the slope has changed from positive to negative or vice-versa).

The content of calibration data file contains the following:

- A table showing data captured from the data grid in the BASS screen
- The linear best fit line offset and slope
- The polynomial terms according to the selected order
- A table of values over the chart range using the following columns
    - Pixel (column A)
    - Wavelength calculated using Linear fit (column B)
    - Wavelength calculated using the polynomial degree (column C)
    - Delta, the difference between the calculated linear and polynomial wavelengths (column D).

It is beyond the scope of this document to describe every analysis possible. Creating a chart using column D, will show the divergence between the polynomial and linear fits. Adding more calibration points at the ends of the chart can stabilise the curve at the extremes. Some divergence is to be expected because spectra will not be perfectly linear.



	A	B	C	D
1	Basic Astronomical Spectroscopy Software Calibration Export			
2				
3	Calibration Data Analysis			
4				
5				
6	Index	Pixel	Waveleng	Error
7	1	15	0	-5.9E-14
8	2	1144	656.28	2.3E-13
9	3	852	486.13	-9.1E-13
10	4	763	434.05	9.1E-13
11				
12				
13				
14				
15				
16				
17	Linear terms			
18	1	-8.89379		
19	2	0.58112		
20	Polynomial terms			
21	1	-8.5311		
22	2	0.56839		
23	3	2.4E-05		
24	4	-1.1E-08		
25				
26				
27				
28				
29	Pixel	Linear fit	Poly fit	Delta
30	0	-8.89379	-8.5311	0.3627

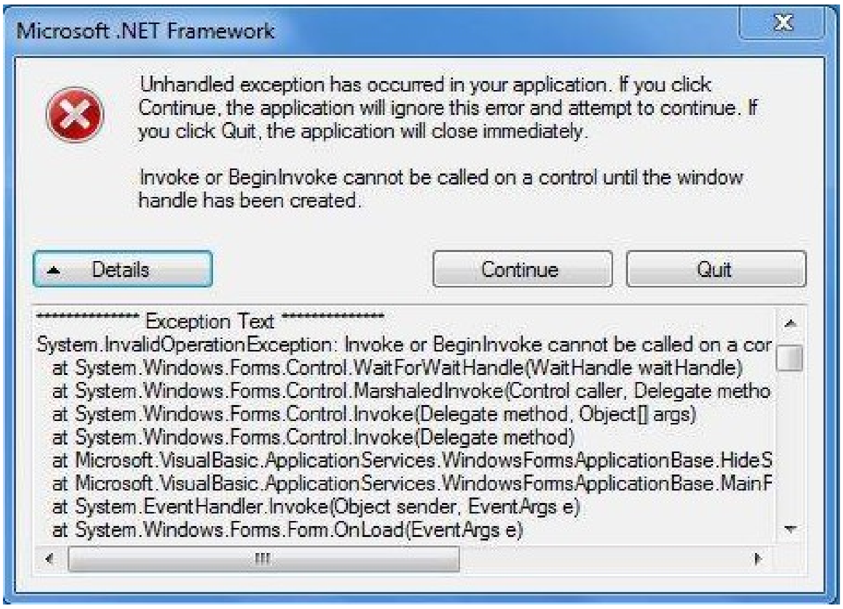
Export complete at 15/08/2012 00:21:18

4 Appendix B - Known issues & Trouble shooting

The known issues are listed below:

1. The chart excludes the number of pixels corresponding to any manual image strip offset alignment for un-calibrated profiles.

2. Intermittently, on application startup, an error message as shown in the image below may be raised. Pressing continue is normally fine. If in doubt restart the application.



Unhandled exception has occurred in your application. If you click Continue, the application will ignore this error and attempt to continue. If you click Quit, the application will close immediately.

Invoke or BeginInvoke cannot be called on a control until the window handle has been created.

```
*************** Exception Text ***************
System.InvalidOperationException: Invoke or BeginInvoke cannot be called on a cor
   at System.Windows.Forms.Control.WaitForWaitHandle(WaitHandle waitHandle)
   at System.Windows.Forms.Control.MarshaledInvoke(Control caller, Delegate metho
   at System.Windows.Forms.Control.Invoke(Delegate method, Object[] args)
   at System.Windows.Forms.Control.Invoke(Delegate method)
   at Microsoft.VisualBasic.ApplicationServices.WindowsFormsApplicationBase.HideS
   at Microsoft.VisualBasic.ApplicationServices.WindowsFormsApplicationBase.MainF
   at System.EventHandler.Invoke(Object sender, EventArgs e)
   at System.Windows.Forms.Form.OnLoad(EventArgs e)
```

3. The image strip view shows a red cross/lines on Windows XP systems when loading a profile or image > 32768 pixels wide. There is also a popup error message. A workaround is to set Image Strip View to one of the stretch modes before loading the large profile. The profile can then still be processed normally using BASS.

4. Out of memory errors can occur when a large amount of images are loaded, especially from a DSLR. A workaround is to crop the images to remove unused regions, normally above and below the spectrum, but allowing sufficient for sky subtraction where necessary. The Bulk Image Manipulation screen provides tools to crop images.

   The 64-bit version allows significantly more images to be loaded that the 32-bit.

5. *Where has my profile gone*? Try the following:

- If sequence position is > 1 then check pixel or wavelength range overlaps that of the chart. Try moving the profile to the top (sequence = 1)

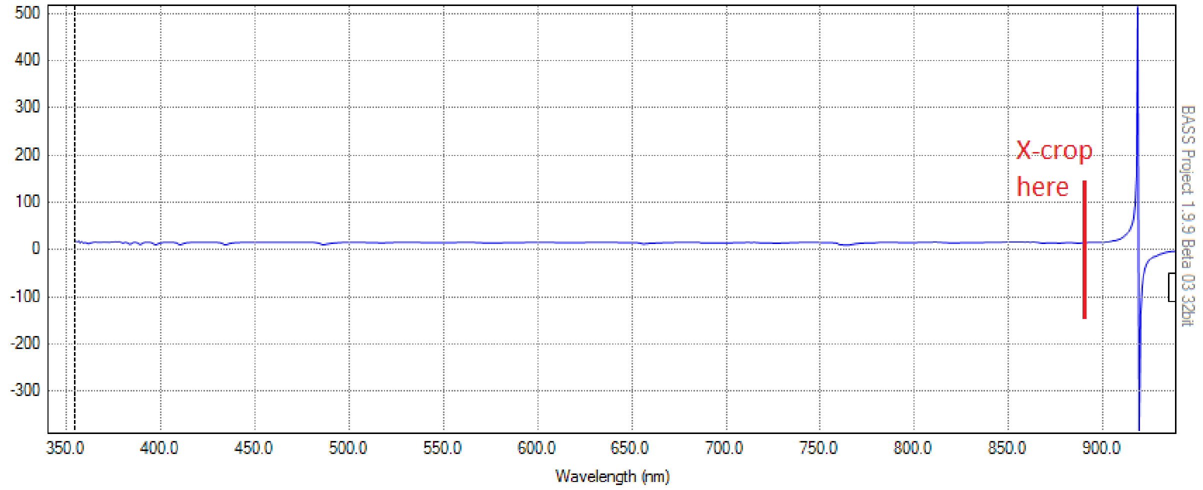
- Check manual scaling range is comparable with the displayed Y-axis range, try enabling auto scaling.

- Check wavelength range in Chart Settings is consistent for your wavelength unit. (e.g. easy mistake to set 380 to 800 when in Angstroms when it should be 3800 to 8000).

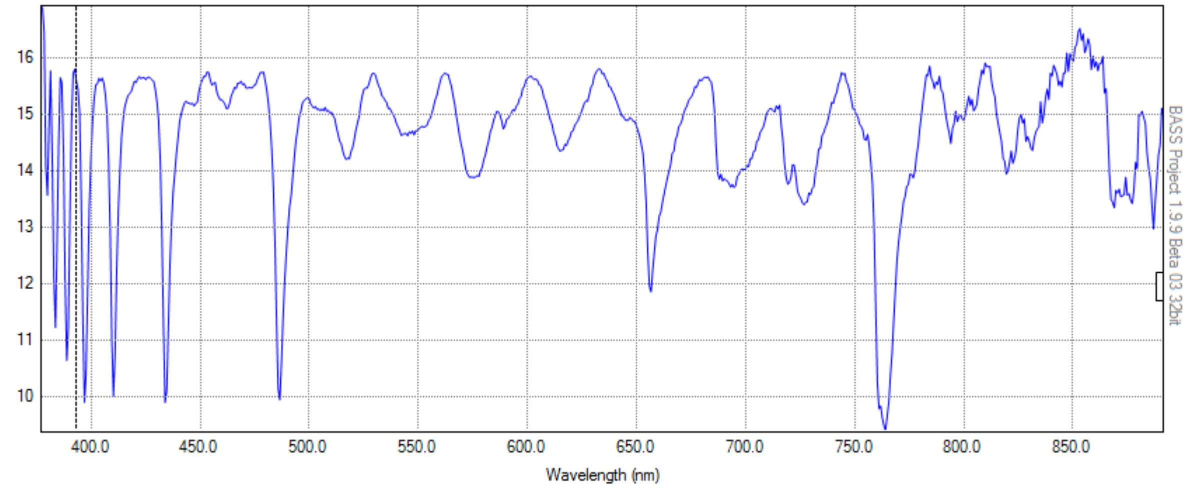
- Check in Profile Properties that the profile is not hidden. (Line Width = 0 and Line Marker = no marker will hide it).

- Check the Line Colour is not the same as the chart background.

- If an instrument correction or continuum removal has been applied, check for inflection at the ends of the chart. Crop the x range displayed if necessary or temporarily disable Response correction to check profile can be seen.



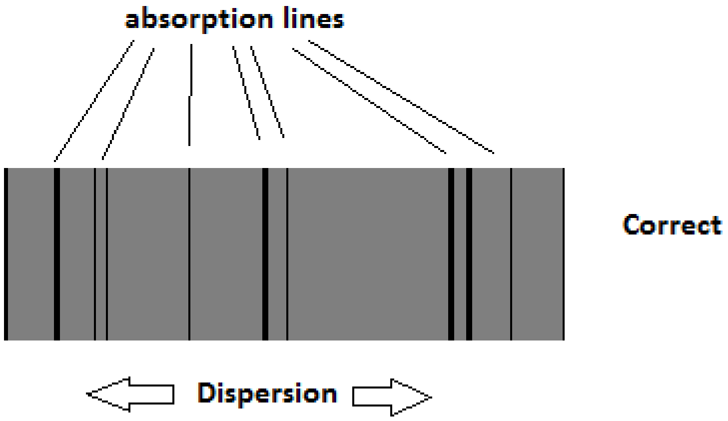
Spectrum with continuum removal is visible once excessive x axis range is cropped



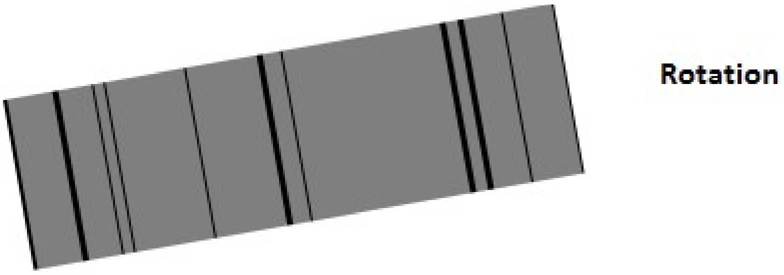
5 Appendix C – Rotate/Tilt/Smile/Slant correction

The following examples illustrate some of the different issues that can be apparent on spectral images and help clarify the terminology used.

The first image represents a correct image where the dispersion is horizontal and the absorption (or emission) lines are vertical.

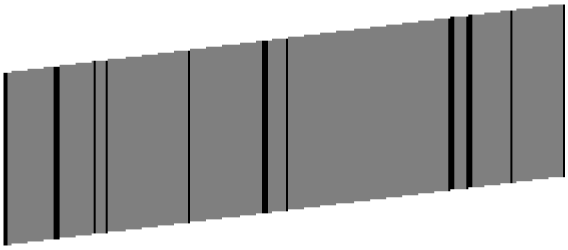


The next image shows a spectrum rotated. The dispersion is not horizontal and the lines are not vertical. This can be caused by the camera not being horizontal to the dispersion axis (of the prism or grating).



The next image shows Slant. The dispersion is horizontal, but the lines are not vertical. This can be caused by the slit not being vertical, or by trailing on a moving target when not using a slit. Capturing a slit-less spectrum without an RA driven mount can also produce slant.

The next image shows Tilt. The dispersion is not horizontal, but the lines are vertical. This can be caused by rotating the camera to compensate for a non-vertical slit.



Tilt

The next image shows Smile. The lines are curved. This can be caused by optical misalignment or other aberrations. This issue is more likely to be seen in Littrow spectrographs. There is also the possibility of horizontal smile.

Smile

Of course, the issues can also appear in combination, for example slant + smile as shown below.

Slant + Smile

6 Appendix D – Amendment History

The amendment history since version 1.9.0 is shown below. Refer to the 1.9.7 User Guide to see earlier amendments from earlier versions.

Version	Notes
1.9.0 (includes 1.8.3 beta changes)	New screens Calculation of barycentric velocity correction using Python PyAstronomy Apply velocity correction - to create a new corrected profile Doppler Utility – calculate between velocity and wavelength change Pop-up dialogs make setting and converting between different formats of date, right ascension and declination easier BeSS Settings screen – Simbad button will populate RA, DEC, spectral type fields (internet connection required). Negative latitude values are made positive (+360) Calibration Lines screen – new Suggest button added. This will make a suggestion of the wavelength of a calibration point (once at least two points have been set). Atmospheric Extinction screen – shows air mass ratio when altitude is keyed Profile Properties – The Correction tab has been renamed to Response
1.9.1	BeSS Settings screen – added Comments tab for comments & history entries. Colour image strip views – RGB channels become white when saturated Bug fix – Site and Equipment textboxes limited to 40 characters Bug fix – DAT files when ‘Save to 1D’
1.9.2	Prototype of Phase Plot screen
1.9.3	New Phase Plot screen A 2d surface plot with wavelength on x axis, phase (or time) on y axis. The colour denotes flux. This requires the PhythonRunFiles folder to be installed. FITS Header screen Text search added for keywords or values Calibration Lines screen New Barycentre checkbox Measurements screen Julian mid-point date field added to reports Barycentre measurement option added X and Y data plot tool added for multiple profile measurement Continuum & Response screen New Linearise checkbox option to force points within a selected region to be in a straight line BeSS Screen Validation added to check projected rotational velocity is 0 to 1000km/s. If yours is negative, you must either set it blank or make it positive for the BeSS database to accept your submission.
1.9.4	Phase Plot screen The 'Show Phase' checkbox has been replaced with a new 'Mode' drop down list in the Y-axis panel. The three drop down list options are:

	- Time Series -This plots elapsed days - Phase - Plots days in a rolling phase period - Sequence - This equally spaces each profile along the y-axis. Since Date-Obs is not used, this option works with DAT profiles Resample screen Bug fix for filter issue on high resolution calibrated profiles. Filtering is now done prior to resampling.
1.9.5	Measurements screen - Include pixel value in calibrated FWHM result. E.g. `FWHM           : 26.262Å (R = 250 @6562.8Å) 7.6981px` - Fix – correction to FWHM on un-calibrated profile when wavelength unit not nanometres Copy binning zone from target to calibration image Uses a new right mouse click context menu option Stack Images screen - Now supports use of dark scaled frames, (where exposure times of light and dark frames don't exactly match. - A new textbox to allow a manual dark frame scaling factor to be applied to dark frames. Needed when exposure times are not in FITS header. - Cosmetic file entry is now included when file list is saved and opened - Master images (now prefixed '_BassMaster') are now only created when there is more than one frame. Prevent invalid starting Pixels Prevent invalid pixels when creating a new profile using a smaller instrument response. For example, when applying a response file whose starting range is less than that of the target profile. Stitching Profiles Fix – Calibration values are now preserved when Save As 1D used Apply Velocity Correction Function is reinstated following issue created in 1.9.4
1.9.6	Stack Images Screen Normalise Flats checkbox is ticked by default General improvements, Min 0 checkbox. BeSS Settings screen Added icon links to BAA Spectroscopic and ARAS databases Validation message fix. If the wavelength used to calculate resolution is provided, then so is Effective SRP. Echelle Extraction screen Now extracts target and calibrations strips, when selections are made using flat image H2O Correction screen New screen to remove features caused by telluric water lines. This prototype is work in progress. Calibration menu

	The ‘New Calibration’ menu option is removed. – Use the ‘Remove Profile’ if necessary then click the ‘Create/Edit Calibration’ option New ‘Use Minimal Calibration Text’ menu option – This displays just the calibration point wavelength. The vertical positions of calibration labels are also staggered to minimise overlap where the lines are congested. Default colour of new profiles changed
1.9.7	UVES file import UVES files, renamed with an ‘.uvs’ extension can now be imported. Once imported they behave as DAT files. Performance optimisation, (resulting from UVES import work), has speeded up: Export of DAT text files, profile measurements and profile resampling. Measurements & Elements screen Now supports element data files having intensity column Element plots can use lines or scaled Gaussian curves Label option includes vertical or horizontal text Element search can use sub filter (ionisation) field. The following settings are now remembered. * Element file name * Significant figures * Measurement report type * Element tolerance * Element label type add * Element label text * Element default colour Labels & Annotations screen. New scaled element line annotation type. Wavelength, Intensity and Element can be edited. Data grid can be sorted by any column Multiple rows can be deleted from Labels data grid Arrow pointer allowed for some line types Bulk Image Manipulations screen Now supports mathematical operation using a 1D profile. FITS Header screen New back and forward navigation buttons make it easier to look at header values across different profiles Limited validation of many critical FITS keywords Cosmic & Hot Pixel screen Option to use ADU threshold or neighbour comparison Option to allow detection and removal of hot or cold pixels Option to specify median or average for correction Tracker bar tooltip info now includes ADU count Bad pixels list show ADU values Black and White levels screen Pixels above white ADU corrected as hot pixels Pixels below black level corrected as cold pixels Screen is now sizeable General – Holding Control key will show mouse cursor position (XY value and flux) on an image Bug Fix – Exposure time edit in BeSS screen would revert to previous value after save.

1.9.8	TFITS and FITS files with a tabular data format can now be read. When a tabular FIT file is detected, the user is prompted to export to multi column data text file to display the profile, (using first two columns only). Raw Image info is now displayed in LH status bar when X > 32768 pixels. Note: Image strip width is physically limited to 65,535 pixels (a .Net framework limitation). RH status bar now allows text to be selected and copied to clipboard More logging added (when LoggingLevel setting = 1 is set in confg. file) Prompt for left or right label alignment to be set when adding molecule bands in Labels screen. Uses default Left where missing. Black and White levels are now reset when creating a 1D profile following flux normalisation BeSS settings – tab sequence updated and latitude/longitude buttons are enabled/disabled according to Site Location. Stack Images - COMMENT keyword without leading "=" 1.9.8b2 – fix false detection of FITS table when EXTEND=T. Logic is now NAXIS=0 and EXTEND=T 1.9.8b3 – fix rounding & superfluous digits for wavelengths entered in Calibration Points screen 1.9.8b3 – BeSS screen. Projected Rotational Velocity field was incorrectly populated with Radial Velocity. 1.9.8b3 – File Menu new options to open recent projects and profiles Correlation of two profiles screen – Work in progress. Needs password, can be supplied on request. 64-bit version First version to be available in existing 32-bit version and new 64-bit version. Reconstruct Image screen uses 32-bit components so wont work with 64-bit version Doppler Utility tab – fix for velocity calculation when value is keyed in observed wavelength text box 1.9.8b4 – Result Option settings in Measurement Options tab of Measurement & Elements screen are saved. Calibration Points screen Calibration data points can be temporarily disabled by making the pixel value negative (by inserting a "–" e.g. 123.45 to -123.45). Region selection tool screen A check box has been added to refresh the chart when the Update button is pressed. 1.9.8b5 Cross Correlation function screen is available for general usage, but still work in progress. Accessing the screen from the Tools menu no longer requires a password. Reconstrct Image A warning message has been added to notify he user that the Reconstrct Image screen will only work with 32-it versions.

1,9.9	BASS Project User Guide - Updated with changes since 1.9.7 - Amendment History prior to version 1.9.0 has been removed - Troubleshooting section has been extended - User Guide fix duplicate section numbers in chapter 2.2 Measurements & Elements screen - Gaussian checkbox added (Measurement options tab) - Reference Lamda drop down list (Measurement options tab) - The summary statistics calculations will exclude invalid values. Stack and Align profiles - Barycentre checkbox added for alignment Chart – minor tick marks - Tick marks on the chart axes can bet set in the X Axis and Y Axis tabs of the Chart Settings screen Date & Time Setter screen – Modified Julian Date - The Date and Time Setter screen now includes a textbox to show and allow keyboard entry using Modified Julian Date Import of ELODIE profiles - One dimensional ELODIE fits profiles can now be imported. Image Strip View On Windows XP operating system, images or profiles with width > 32767 pixels are always displayed in Stretch mode regardless of the setting in the Image Strip View drop down list. The reasoning is concerned with limitations of Windows XP. Configuration file setting to use zero for Empty data points The default behaviour of BASS is to ignore Empty data points when rendering image profiles. Empty values are seen as NaN in the Edit Profile Values screen. The following setting added near the end of the BASSProject.exe.config will substitute 0 for Empty values when an image is loaded.

```
<setting name="RawNaNAsZero" serializeAs="String">

    <value>True</value>

</setting>
```

1.9.9b3	Bug Fix: BITPIX must be second keyword (fix to profiles created in the Resampling screen) FITS header: Keyword BAS_MEX for BASS Project Universal Mid-exp Date added File menu: Maximum number of recent profiles and projects increased from 15 to 25 Chart settings: Can be edited to be edited when no profiles are loaded. Profile Properties: File Rename message makes it clearer that a new filename must exclude path. Region Selection tool: now includes a Cross sectional plot Cosmic Hot & Cold poxels screen – Now supports bad row and bad columns in Cosmetic file. Bad pixel can be manually set at double click position (without

	needing to be detected). Stack Images screen: Cosmetic file is applied to all light, dark, flat, bias and flatdark images.