BENWIN+
Version 3.0

USER MANUAL

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Contents

1. Introduction to Benwin+

Benwin+ is a windows software designed to control Bentham's range of monochromators, detection electronics and accessories.

On running the software, initiating an initialisation procedure establishes communication with the hardware. Benwin+ then reads a file of type *.cfg, (entitled system.cfg by default). This file describes the elements of hardware to be controlled and their GPIB address.

By default a *.atr file of the same name as the *.cfg file used is looked for. This file describes the parameters of the instruments of the system.

To provide greater flexibility in migrating between configurations, a configuration manager is provided which stores system hardware and measurement settings.

Features include:-

• User initiated or time-delayed spectrum scanning (schedules)

• Easy system calibration, irradiance, radiance, detector responsivity etc

• Obtain spectrally integrated quantities (candelas etc)

• Instantly obtain colorimetric data

• Perform transmission, absorption and reflection measurements

• Perform simple arithmetic functions

•Add-on for control of translation stages, goniometers, data acquisition from other instruments etc

•Direct export of measurement data to excel, with capability of running macros

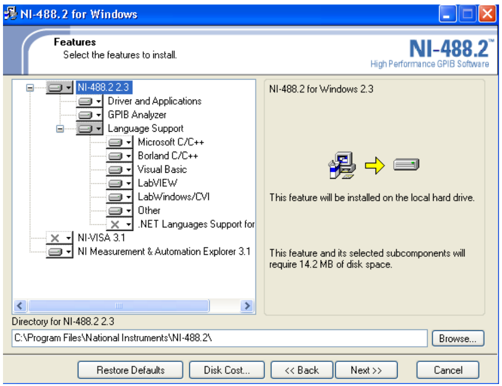
The software can also be run in stand-alone mode to view measurement results at a later time.

The following sections will be divided into configuration, measurements, analysis and menu reference.

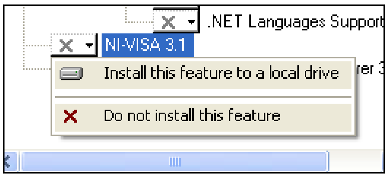
2. System Configuration

2.1 NI USB-GPIB installation

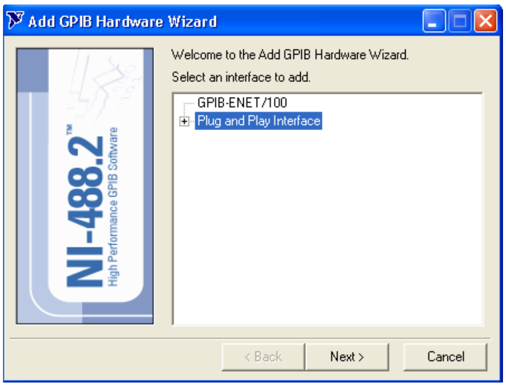
•Insert NI488.2 CD into computer, setup will auto-start
•Select installation
•Hit next to continue installation
•Hit next to confirm default software installation point
•For installation select **CUSTOM** then hit next to see the following



•It shall be noted that NI-VISA 3.1 is not automatically installed, whilst this is necessary for operation of Benwin+
•Right-click on the pull down menu to the left of this entry and select "install this feature…"



•Before continuing with the installation ensure that VISA does not have an X marked to its left
•Hit next, agree to terms and the software shall be installed.
•Decide whether you wish to register the software then hit next
•On the add GPIB hardware page, highlight "plug and play interface"



•Hit next
•Select shutdown and click finish
•Connect USB-GPIB to computer
•Power on computer
•If using XP it is necessary to go through the "found new hardware" process **TWICE**
•You can run the NI getting started wizard, found on power up to ensure good function

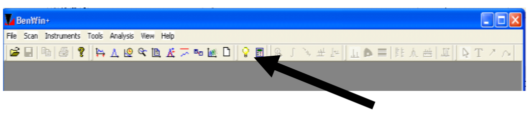
2.2 Installing Benwin+

•Insert Benwin+ CD into computer, and double–click on setup. This takes you through the setup process, select complete installation
•A Bentham/ Benwin+ folder is created in c:/program files (local hard disk)
•A shortcut to Benwin+.exe shall be found also on the desktop

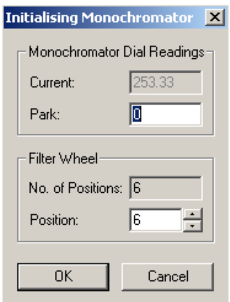
2.3 Getting the software started

Tools/ Initialise

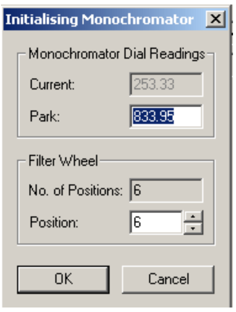
•Run Benwin+.
•Firstly, initialise system by either going to Tools/Initialise or clicking on light bulb icon shown below:-



•For the first time, you shall be shown the following window:-



•It is necessary to input in the park (highlighted) position of the monochromator, then hit OK
•Whenever you initialise in the future this number shall already be present, simply hit OK



•The system is now ready for use.

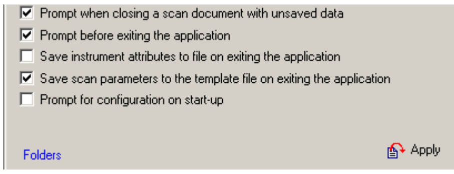
3. Instrument attributes

Instruments

3.1 Introduction

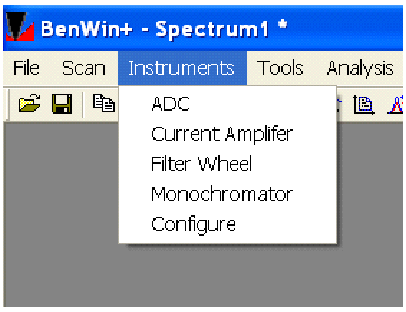
The instruments menu lists the system components, giving access to their properties.

Note that these properties are saved in the attributes file. On closing Benwin+, by default any changes made herein are saved. This default can be removed by going to tools/ options and de-selecting "save instrument attributes to file on exiting the application". Hit apply.



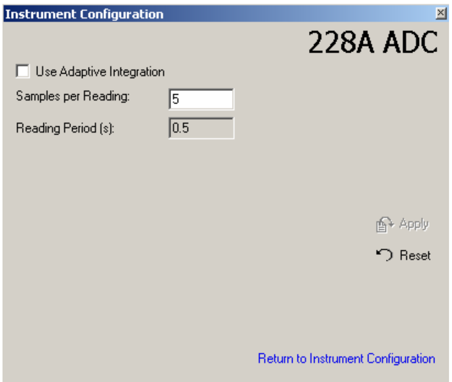
Should one desire to have a number of configurations having different instrument attributes, having made the required changes, go to instruments/ configure/ advanced>> and save new system attributes under a different name. Please see §2.4.8 for further information in using Benwin+ with alternate configurations.

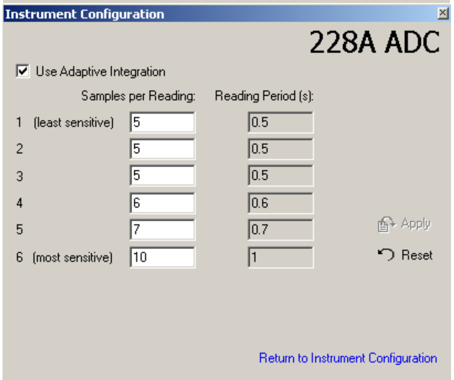
Furthermore, in Instruments/ configure/ advanced>> via a bottom right hand link one can access a link to change the instrument names field should this be required.



3.2 228A Analogue-Digital converter

The 228A ADC integrates over 100ms periods. One can choose how many of these periods shall be taken to determine the reading at each wavelength.





A good number to use for reasonable signal is 5 averages.

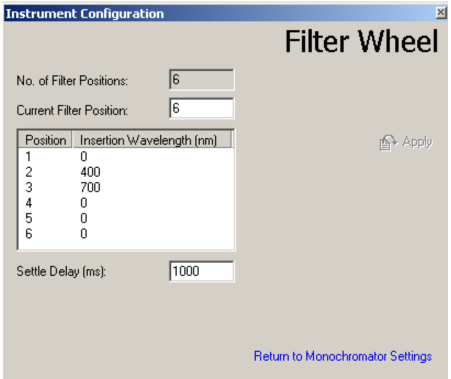
One may also select adaptive integration which permits varying the number of averages taken as a function of the gain range of the current amplifier, fewer averages in the low gain ranges and more in the higher gain ranges to smooth out noise.

3.3 Filter Wheel

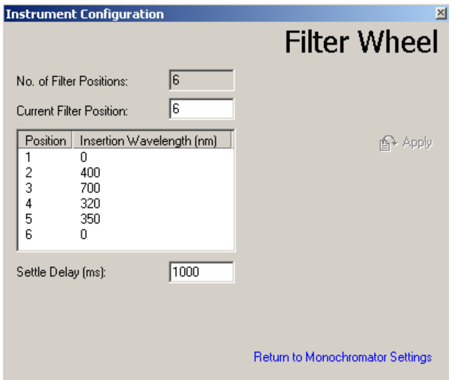
The filter wheel has six positions, populated as standard as follows:-

Position	Filter	Insertion (nm)
1	Open	0
2	OS400	400
3	OS700	700
4	Open	-
5	Open	-
6	Shutter	-

The filter wheel page is as follows.



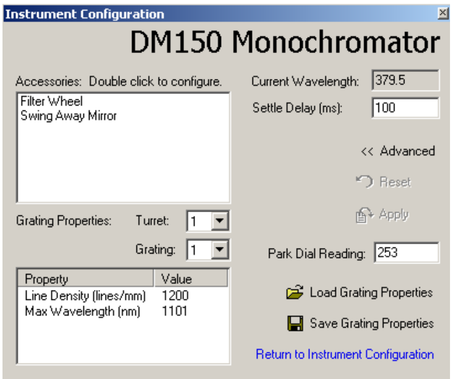
In this system where ND filters are employed, the insertion wavelength of the ND filters can be changed as appropriate by simply typing the new value in the above and applying, for example,



The settle delay is the pause taken by the system following each action. 1000ms is sufficient.

3.4 Monochromator

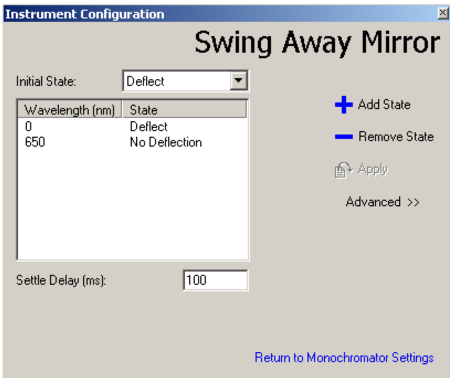
Selecting this page gives access to the parameters of the monochromator. Selecting Advanced>> gives access to the grating properties, line density and maximum wavelength. For this system, 1200g/mm gratings are employed with a maximum wavelength of 1101nm.



A settle delay of 100ms is sufficient.

3.5 Swing Away Mirror (SAM)

Accessed via a link in the monochromator page is the SAM page.

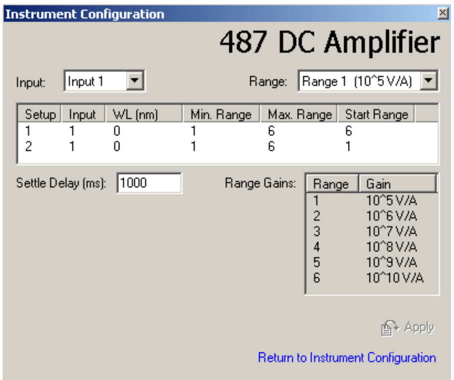


Here, one might add (+) a number of states (or remove by highlighting and hitting -). Define states by the wavelength of insertion (inclusive), and the SAM state. In advanced>> can be named the two SAM states for easier setting up.

Settle delay of 1000ms is sufficient.

3.6 DC Amplifier

The properties page of the DC pre-amplifier is as follows:-



The only items to change in this page are the min/max and start ranges of the amplifier and the settle delay.

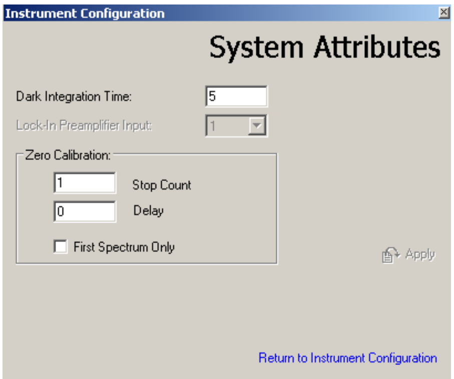
In this system, it is recommended to use all ranges, 1 (min) to 6 (max). Set the start range as the max range.

A settle delay of 1000ms is sufficient.

3.7 "Miscellaneous"

The miscellaneous page is as follows.

The dark integration time, the time over which dark current is integrated is factory set to 5 seconds and should be sufficient.



3.8 Configuration settings

Tools/ Configurations

The configuration function of Benwin+ is used to make going between measurement parameters more flexible.

The parameters that may be modified are:-

•Scan settings, range, step size, data correction etc
•Instrument parameters, as saved by atr files.

To set up a configuration setting, it is merely required to setup Benwin+ as one would do to perform a scan, that is to say initialise, have the required atr file loaded, the required scan parameters loaded, the required data correction file (or none) loaded, then:-

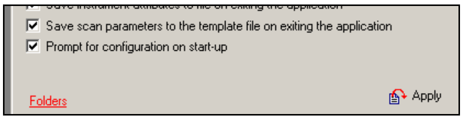
•Go to tools/ configurations
•Hit save
•Name configuration, enter
•Type reference note if required
•Hit OK

This can be repeated as often as necessary. Note that to operate the xml files must remain non-write protected.

Now, configurations can at all time be accessed by going to Tools/ configurations.

Highlight the required configuration, and hit use to select.

One can force Benwin+ to display the configurations page each time the software is started by going to Tools/ Options and checking the bottom entry prompt for configuration on start up.



4. Measurements and utilities

4.1 Introduction

Benwin+ is a general purpose spectroradiometer software, wavelength scans being its habitual use. Other functions include setting the monochromator to a given wavelength, timed scans at a given wavelength, scans according to a schedule, system calibration, and relative measurements.

Spectral scans involve the initial measurement of the system with respect to a reference. This reference may be a lamp of known output, a reflectance standard or a 100% “no-sample” measurement.

By comparing the measured signal obtained as a function of wavelength with the reference, can one determine the nature of an unknown sample.

The system therefore effectively measures the detector photocurrent under stimulation by the source, as a function of wavelength, which is therefore a convolution of the source output, the spectral response of the input optic, the monochromator (mirrors and diffraction grating) and of the detector.

As shall be seen in the next section, an advanced menu gives access to change items such as zero

4.2 Hardware operation

The initialisation procedure establishes communication with all hardware components, and moves the monochromator to a known reference point. For M300 and DM150 monochromators, the gratings are moved to a maximum positive limit the corresponding wavelength of which should be input to the software at installation. For (D)TM300 monochromators, the procedure moves the monochromator moves the turret to a negative mechanical limit, the software being instructed via the system.atr file the number of steps from this point is the zero-order position of a given grating.

Now, in most system there exists a filter wheel, in position six of which is a blank to shut off the input to the monochromator. This is used in the determination of the detector dark current, and to protect the detector from continual exposure.

When scans are launched, it is important to perform the zero- calibration procedure.

This procedure shuts the input to the monochromator. In the first instance sets the current amplifier to maximum gain range (ranging to a lower gain range if this range is in overload). When stable, the output of the ADC is read. This constitutes the detector dark current. The current amplifier is then set to its' minimum gain range, and the ADC read. The signal measured does not come from the darkened detector at this point, what is registered is the offset of the detection electronics. The 20,000 count ADC has ~400 counts reserved for negative-going noise signals. With no stimulation therefore, the system should read ~400 counts. It is important to realise the importance of ensuring this offset is taking into account. Consider for example a large signal in a higher gain range, say 18000 counts, ranging to a lower gain range, where the counts may be 1800. The relative impact of not subtracting the 400 count offset leads to discontinuities in the spectrum should zero-calibration not be taken into account.

Should zero-calibration be not selected, provided that the system has performed at a previous point this routine, the same values shall be carried through at all times. This is not recommended, particularly in the case of for example photomultipliers, whose response is very temperature and condition dependant.

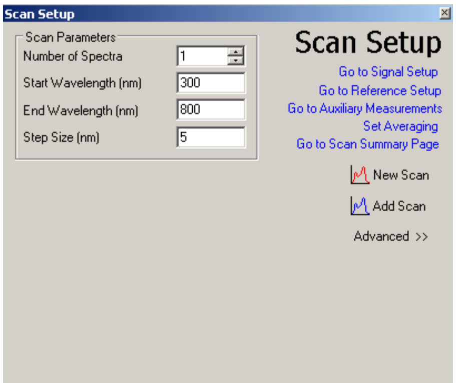
In the scan parameters page, it is recommended that the zero-calibration routine be applied, that the amplifier be permitted to auto-range, that the shutter is closed post-scan, and that the monochromator is returned to the start wavelength for the next measurement.

Furthermore, where add-on modules are employed, ensure that appropriate pre-/ post-scan module fields are selected.

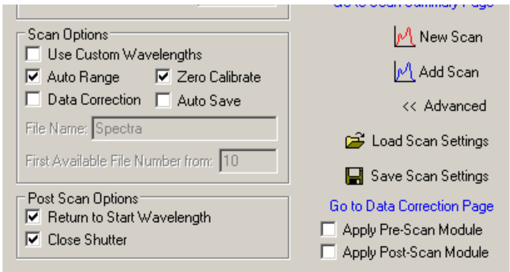
4.3 Scan setup

Scan/ Scan setup

Spectral scans are initiated by going to the Scan menu and selecting Scan setup to reveal the following:-



•Enter the wavelength range required
•Select bandwidth required
•Select number of scans required
•Click on advanced>> for further features:-



•Ensure that zero calibration is selected. This determines ADC offset and dark current at beginning of scan.
•Ensure that autorange is selected, permitting the amplifier, to change gain range where appropriate.
•It is of good practice to have close shutter and return to start wavelength selected.
•Should it be desired that all spectra are saved, select auto save and define file name prefix and number suffix
•Click on new scan for measurement.

When performing initial measurements of a calibration standard, ensure that data correction is not selected- this uses the calibration mode of the software not required at present, the y-axis of the scan window once launched should read Signal (nA).

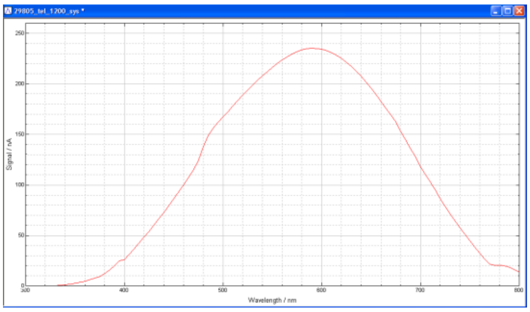
Having performed measurements of the calibration standard, and having implemented a correction (see below), ensure that data correction is selected to determine the corrected output of unknown sources.

The following window shall be seen in the foreground, detailing the progress of the scan, whilst a spectral plot will appear in the background.

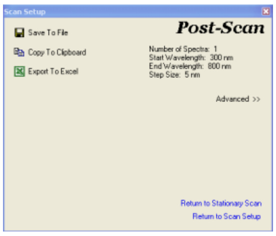
The shape of the uncorrected scan will vary depending upon source, gratings, etc, but it is normal that there be relatively sharp features, with loss of response towards the ends of the spectrum.

Furthermore, a slight discontinuity may be seen at the insertion of order sorting filters.

All of these features “calibrate out”.



At the end of a scan, you shall be presented with the following screen.



At this point one may, if desired choose to export the spectrum to excel (either for viewing, to perform calculations or to run macro which may be specified), or one may simply close this window. Please see §5-8

If autosave should not be selected, ensure that the current spectrum is saved.

4.4 System Calibration

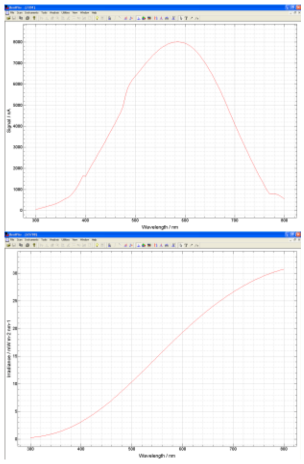
Scan/ Data correction

The measurement of any unknown source with a spectroradiometer, or the response of an unknown detector means nothing without comparison to a standard such as those obtained or compared with scales as defined for example by the National Physical Laboratory.

Such measurements require a first scan of a standard prior to measurement of the unknown device.

An example of this can be seen in the following figure, the irradiance of a lamp being required.

The upper scan is the throughput of the monochromator system when viewing the unknown lamp, having actual irradiance displayed in the lower spectrum.



The ratio of the calibration data showing the true device spectrum, to the system measurement, yields a wavelength dependant system correction factor. All future measurements ought to be multiplied by this correction curve to yield a true reflection of the source unknown device spectrum.

This rationale applies for the determination of detector responsivity.

It is also of importance to reflect the quantity of the calibration measurement, whether it be irradiance, radiance etc.

This correction, and subsequent presentation of data in correct quantities and units, is implemented in Benwin+ via the data correction page.

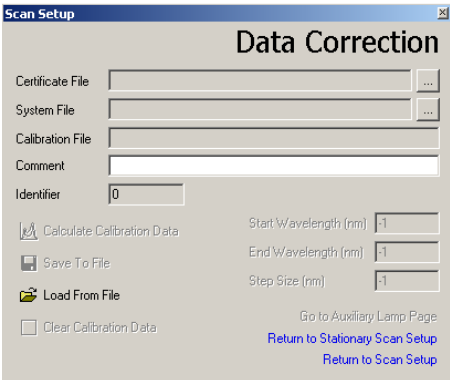
Firstly to apply data correction two files are required-

•A *.bcf Bentham certificate file of the source calibrated results with measured quantities and units
•A *.ben, system file, measurement of the unknown device in the same step

The procedure is as follows:-

•Perform scan over desired spectral range of standard source

•Ensure that data correction is not selected and that the units of the measurement are in nA
•Save scan.
•Go to Scan/ data correction page.

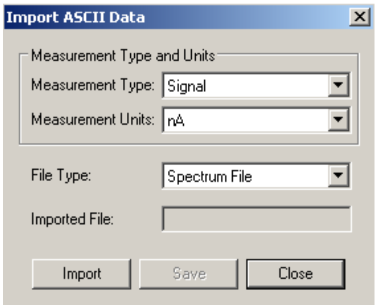


•Using … button select appropriate *.bcf file for device
•Select just-saved scan as system file.
•Hit Calculate calibration data.
•Save to file
•When prompted do you wish to apply data correction click YES
•Return to scan setup, and then scan as normal.
•Note that the y-axis should reflect the correct quantity to be measured.
•Ensure that the next time that a comparison to standard be performed, that data correction is NOT selected.

One may view the *.bcf file by selecting open/ all files and find the bcf files in the Benwin+ calibration folder.

If you have no bcf file, you can create one by the following process.

•Prepare your calibration standard data as a two column ascii file with no header nor footer, wavelength in the left column, measurement in the right.
•Save this file.
•Go to Benwin+, file, Import.



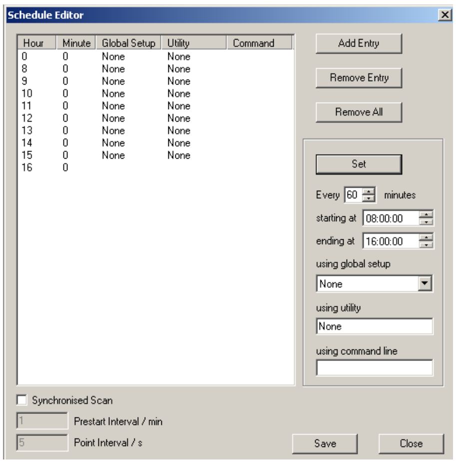
•Select units and quantity of measure, select certificate file and import.
•Chose the file of your data and save in the Benwin+/ calibration folder.

4.5 Scheduled Measurements

4.5.1 Setting a schedule

Tools/ Configure schedule

Unattended measurements may be configured in the Tools/ configure schedule mode.



The only parameters required in this system is the time.

When file ready hit save, and save to schedules folder. File extension *.sch.

One can edit more easily in excel for example, save as text then save in notepad as all file, *.sch.

4.5.2 Running a schedule

Tools/ Schedule mode

To set off schedule, return to tools/ schedule mode and select saved schedule file.
The status bar at the bottom of the screen indicates when the instrument is operating in scheduled mode. The time of the next acquisition is also indicated.

Schedules shall repeat at the given times each day until stopped.
The files acquired during scheduled mode are automatically saved with a filename of the type year-month-day_hour-minute.ben e.g. 20050514_1450.ben
The Schedules contains a log file of each days scheduled spectra - *.log. The log file lists the filenames of the acquired spectra, the start and end time of each spectrum, the detector dark current, the temperature and the detector high-voltage reading for each spectrum.
Please note that Benwin+ must be closed between the initiating of two different schedules.

4.6 Reference Measurements

Scan/ Reference setup

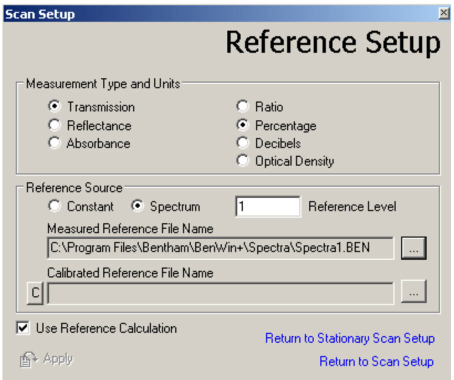
Reference setup can be found in the scan menu. This permits the direct measurement of transmission, reflectance and absorbance of samples.

No calibration correction is applied here. Of interest is the comparison of the raw measured signal with either no sample (for transmission and absorbance) or a standard (for reflectance) in place, and then with the sample under test in place.

In the case of reflectance, the standard used may be presumed to have 100% reflectivity, or one can specify a calibration file with the true reflectance of the standard. This file should be in absolute units.

The measurement procedure follows:-

•Go to scan/scan setup
•Ensure in advanced>> that data correction is NOT selected
•Perform scan over required spectral range
•Save file
•Go to scan/reference setup



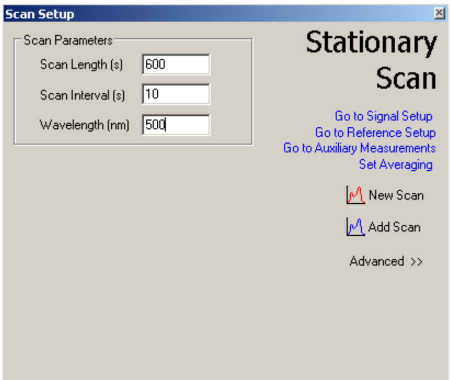
•Select required measurement type and unit
•Select reference to apply , constant (inputting reference level) or spectrum
•Use "…" to load just saved reference spectrum
•In the case of reflectance, should a calibration file be held for the standard, load this file using the …
•Select use reference calculation
•Return to scan setup
•Perform scans in the usual manner
•To use another reference file, use the … button to select other file
•To perform a new reference level, ensure that "use reference calculation" is switched off
•To switch of calibration correction, hit C button to remove file

4.7 Stationary Scans

Scan/ Stationary scan setup

It is possible to perform time-based scans at a fixed wavelength. This is particularly interesting when for example monitoring a lamp to determine warm- up stabilisation period, or for example to measure the transmission of a photochromic material during or after activation.

Go to scan/ stationary scan setup to reveal the following:-



Define scan length, scan interval and monitor wavelength. It is sometimes useful to perform a spectral measurement of an unknown source beforehand to determine the spectral output, and therefore to determine the wavelength of monitoring.

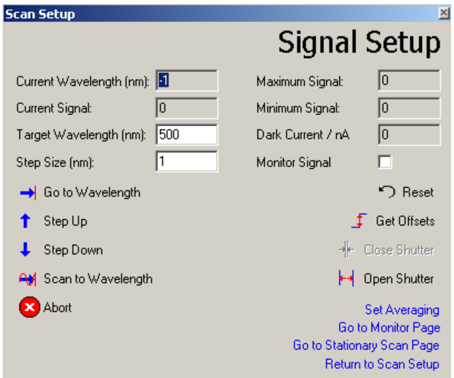
In advanced, one can select whether data correction be applied or not. Ensure that auto ranging and zero calibration are selected for correct measurement.

The scan interval should not be less than the ADC read interval.

4.8 Signal Setup

Scan/ Signal setup

The signal setup page permits moving the monochromator to a given wavelength, of use for certain measurements, and also useful when aligning optics.



Input the desired wavelength in Target Wavelength and hit Go to wavelength. Note that one might monitor the zero order contribution by typing 0 for the wavelength.

Note that here there may be a large signal which may be of consequence with the detector in use (particularly if a bi-alkali photomultiplier is used, for which high signal stimulation might cause hysteresis effects).
Once at the given wavelength, the filter wheel opens the shutter. Selecting the monitor signal box ranges the amplifiers to determine the current signal.

One might also define a step size, and manually scan over a spectral range by hitting the scan up/ scan down buttons. Note that the monochromator control is designed such that a given wavelength be reached in one direction only, that of increasing wavelength. This is to ensure the best wavelength calibration. When scanning down the wavelength scale, the system goes beyond the wavelength selected to approach in the increasing direction.

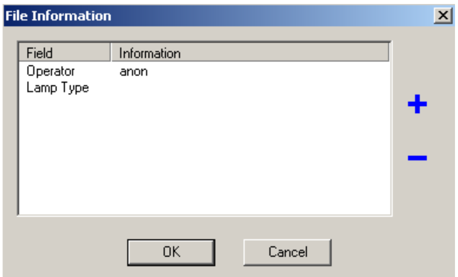
4.9 Signal monitor

Scan/ Signal monitor

The signal monitor opens the shutter and monitors the signal at the current wavelength. A graphic with auto-ranging y-axis shows the current signal and is update as fast as possible.

4.10 Set file information

Scan/ Set file information



One can associate information with each scan by going to Scan/ file information. Here one can define a number of fields hitting the + button, double clicking on the field entry on each line to edit to, for example, Operator, Lamp type etc. One can pre-define the file information to prevent re-typing information common to each measurement. Highlight and hit the – button to delete a field.

With Use file information selected, on starting a new scan a window prompts for the entry of the required file information values. File information is saved with scan data.

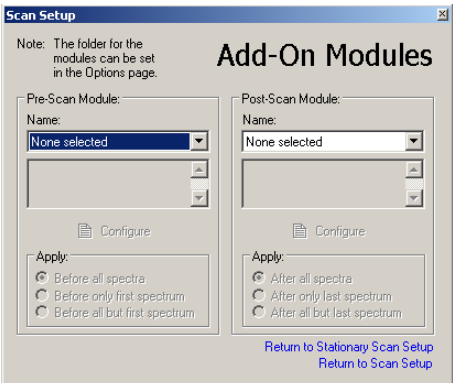
4.11 Add-ons

Scan/ Add-on modules

In order to increase the flexibility of a given system, add-on modules permit the interfacing of for example the control of further instruments, as part of Benwin+, or specific data analysis post-scan.

A guide to add-on modules is provided in appendix 3, for further information, please contact Bentham.

Add-on module dlls should be placed in the Benwin+/ Add-ons folder. They can be implemented via the add-on modules page, and selected as either pre- or post- (or both) add-on modules. Pre-scan modules are used in instances where control or measurement during scans is required, post-scan modules when calculations are involved.

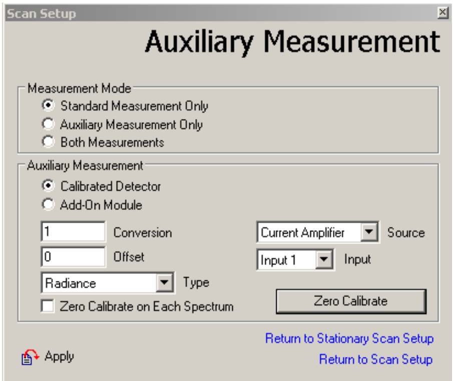


4.12 Auxiliary measurements

Scan/ Auxiliary measurements

It is possible to collect data from a source other than the principal monochromator detector. This source might be obtained via either a Bentham two input current amplifier or relay unit, or via an add-on.

Should a calibration factor be associated with this auxiliary measurement, this may be defined via this page.



Define whether standard, auxiliary or both measurements are to be performed.

Define whether a calibrated detector or add-on module is employed.

Data are acquired at each point in the ranged defined as a scan.

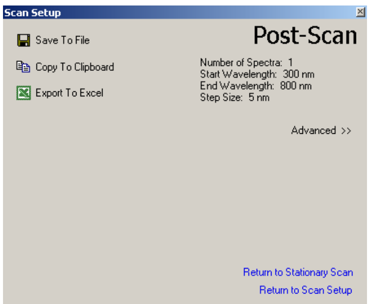
Should a calibrated detector be employed, it is of question to define the source, input, conversion factor, offset and measurement type. Covering the detector, one can hit the zero calibrate button to take the dark current of the source.

The measurement type can be either

•**Radiance** – mW sr^{-1} m^{-2} nm^{-1}
•**Radiant Intensity** – mW sr^{-1} nm^{-1}
•**Irradiance** – mW m^{-2} nm^{-1}
•**Radiant Flux** – mW nm^{-1},
•**Detector response** – A W^{-1} nm^{-1}

4.13 Post-scan

A scan having finished, one is presented with the following window:-



If autosave was not selected, save the file now.

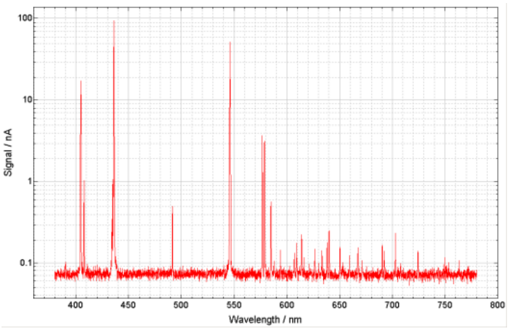
In the following sections are given information on the three Benwin+ data views, and the direct exportation of results to Excel.

5. Spectrum View

View/ Spectrum

5.1 Introduction

This default view presents a view of the spectral distribution of the source, as a function of wavelength (or as a function of time in the case of time-based scans).



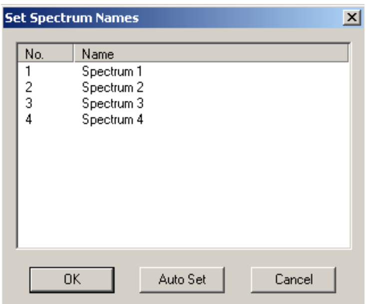
Having performed a scan, within this view the data may be analysed via functions in the analysis menu, or using a right mouse key short cut button.

These functions follow, starting with the analysis menu.

5.2 Set spectrum names

Analysis/ Set spectrum names

One may either autoset file names or change each entry manually.

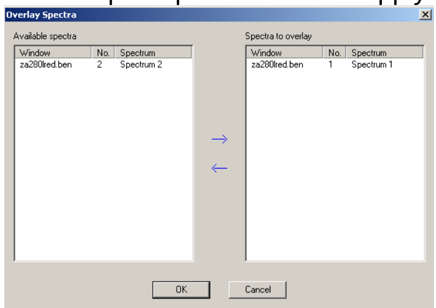


5.3 Overlay spectra

Analysis/ Overlay spectra

Having more than one spectrum window open, it is possible to superimpose selected scans into a given window.

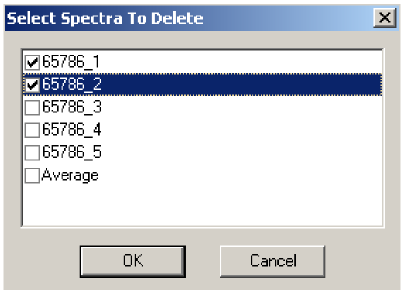
Those available spectra are found in the left hand window, may be highlighted and the → arrow used to place the spectrum in the list to superimpose. Hit OK to apply.



5.4 Delete spectra

Analysis/ Delete spectra

One may delete spectra from a multiple-spectrum window. Check off spectra for deletion, hit OK.

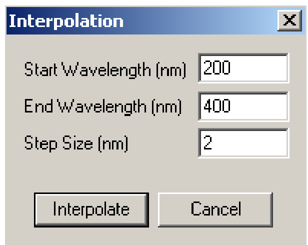


5.5 Interpolate

Analysis/ Interpolate

One might apply a cubic spline to interpolate (or extrapolate) given spectral data.

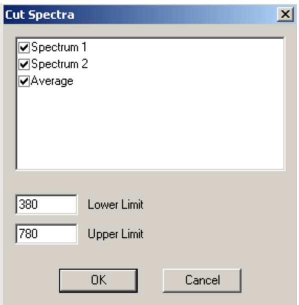
•Go to analysis/ interpolate
•Modifying the start or stop wavelengths truncates the scan
•Enter the desired step size.



5.6 Cut

Analysis/ Cut

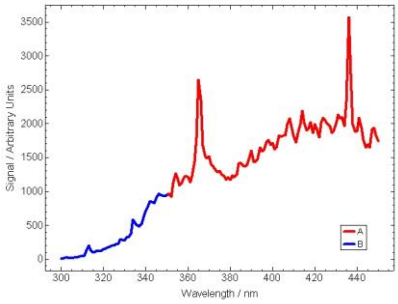
Check off from the list the spectra desired to truncate, define the lower and upper limits, then hit OK.



5.7 Concatenate

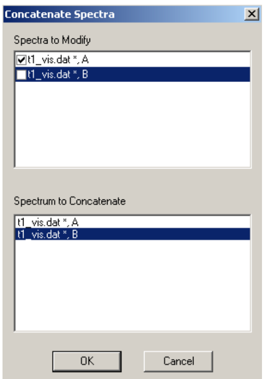
Analysis/ Concatenate

One can concatenate two spectra, to obtain a single spectrum.



.

The spectra need not be continuous, but where a sub-set of the values are not exclusive, the latter sub-set is not modified, the remainder of the set being concatenated.



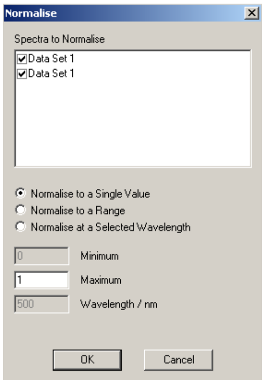
5.8 Invert

Analysis/Invert

Select to obtain a mirror image in the plane of the x-axis of a given spectrum.

5.9 Normalise

Analysis/ Normalise



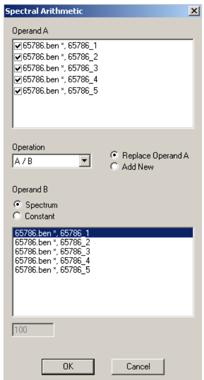
One may normalise selected spectra to:-

•A single value, defined as the maximum,. set usually to unity
• A range, define maximum and minimum limits
•A selected wavelength, define the wavelength and the maximum wavelength

5.10 Spectral arithmetic

Analysis/ Spectral arithmetic

Having one or more scan windows open, one can perform simple arithmetic, either multiplying a spectrum by a constant or another spectrum.



With the window of the first spectrum active, go t o Analysis/ spectral arithmetic

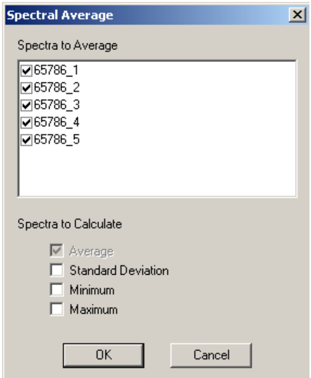
Select the spectrum (or spectra) for OperandA, the operation required, and for OperandB select either a constant (defined lower) or another spectrum.

Select Replace or add new spectra, then OK.

5.11 Spectral average

Analysis/ Spectral average

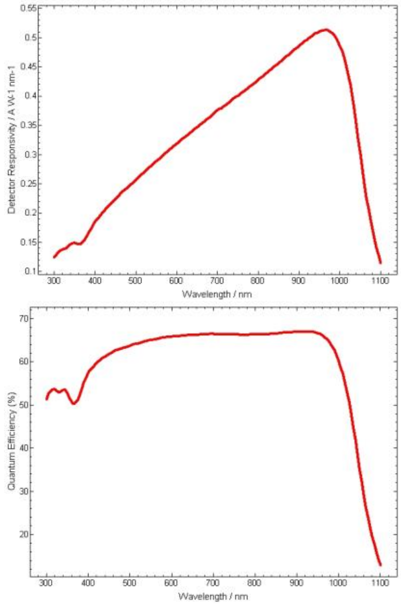
Having performed a number of scans of a given source, one can perform a spectral average, determining also the standard deviation and two spectra based on the minimum and maximum values at each point. These results are labelled accordingly, and are presented on the active spectrum window.



5.12 Quantum efficiency

Analysis/ Quantum Efficiency

In the case of detector responsivity (A W^{-1} nm^{-1}) the responsivity results may be converted to quantum efficiency, defined as the ratio of electrons extracted for the number of incident photons. This process is non-reversible, ensure that the original detector responsivity has been previously saved.

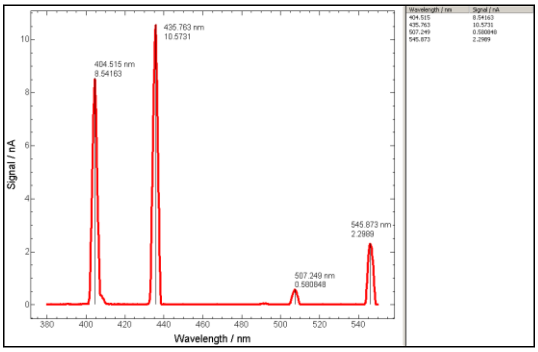


5.13 Peak picker

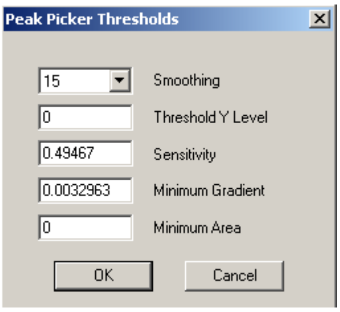
Analysis/ Peak Picker

Having performed for example a scan of a line source, the peak picker function may be used to determine the wavelength position of these peaks**.**

Typically using the auto-settings function should find the peaks present. The results are noted on the graph, a measurements window to the right of the spectrum window also displaying the results.



Should certain peaks not be found using the auto settings, then the set thresholds window can be accessed.



The functions are as follows.

Using the auto-settings function overwrites all changes to thresholds.

Smoothing: Reduces errors due to a noisy spectrum. Broad peaks should be smoothed with a larger number of sample, the converse for narrow peaks.

Threshold Y Level: Enables the rejection of peaks whose height above a local baseline is below that value.

Sensitivity: The Sensitivity threshold allows the user reject peaks whose absolute height is less than a set value.

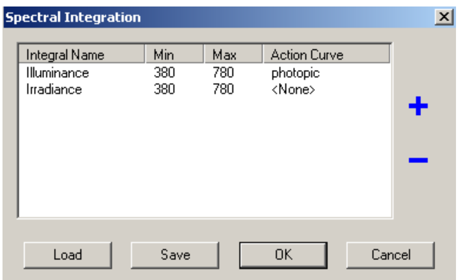
Minimum Gradient: The Minimum Gradient (Value >0) threshold is used to define the peak edges. Points at which the absolute gradient are greater than the Minimum Gradient are considered to be peaks.

Minimum Area: Peaks with an area less than the Minimum Area are rejected. This discounts delta-function peaks such as caused by cosmic events.

5.14 Spectral Integrals

Analysis/ Set spectral integrals

Spectral integrals and action spectra can be applied in the Analysis/ Set spectral root.



+ add integrals, define name, spectral range, and action spectra. Action spectra are two-column ascii files (wavelength, value) saved as *.ACTION in Benwin+ folder.

One may define a group of integrals and save for use later.

For the first time go to Analysis/ Calculate spectral integrals to view results.

Thereafter, Benwin+ will present results automatically. The data are also saved in the *.ben file.

5.15 View menu

Through the view menu, one can toggle to further views as described in the following sections, as well as looking at spectral data and viewing/ adding markers and cursors to determine the positions of features.

Markers may be automatically positioned using the peak pickers function or via cursors.

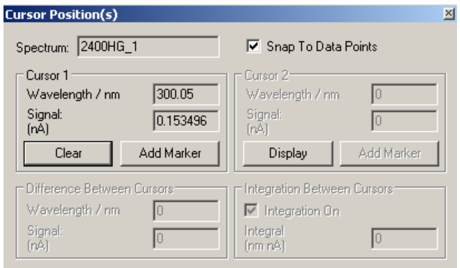
View/ Spectral data

One can view the numerical data by selecting view/ spectral data. Re-select to remove the measurement data.

View/ Cursors

One can place up to two cursors on the canvas of the spectrum to manually probe the measurement results.

The cursors are accessed via view/ cursors.



Controls of the two cursors are on either side of the window.

Hit display to obtain the cursor which may be dragged in place with the mouse. The wavelength and signal of the cursor position is displayed.

One may choose to add a marker at that position. When two cursors are active, the lower section of the cursor window shows the difference and integration between the cursors.

When multiple spectra are present in a given window, the keyboard up/ down arrows selects the curve under consideration.

Hit clear to remove the cursor from the graphical view.

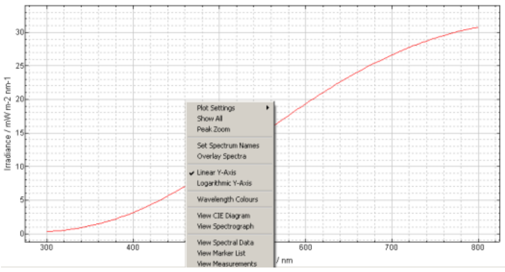
View/Marker list

Provides the user with a list of extant markers in a window.

5.16 Further features

Further menu features, including short-cuts to some of the above are obtained from a menu activated with right mouse click over a spectrum window.

These items are as follows:-



Plot settings: Define the aesthetic aspects of the graph, line colours, labels etc.

Show All: A zoom is provided by pushing left mouse button, holding down the button one can create a zoom box whilst moving the mouse to view a particular region of the spectrum. Show all returns to a view of all data.

Peak Zoom: Automatic finding and viewing of peaks

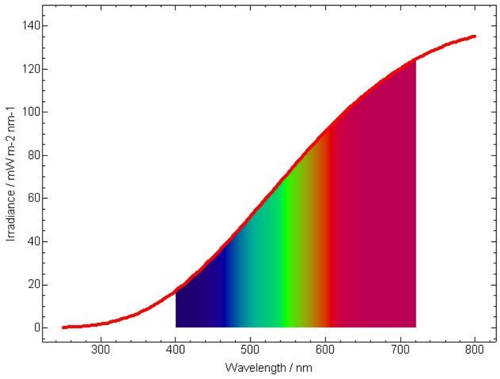
Set spectrum names: See §5.2

Overlay spectra: See §5.3

Linear/ lograthmic axis: Set y-axis as linear/ logarithmic axis

Wavelength colours:

Superimposes wavelength colours to a scan over the visible region.



View CIE/ spectrograph: Toggle between views

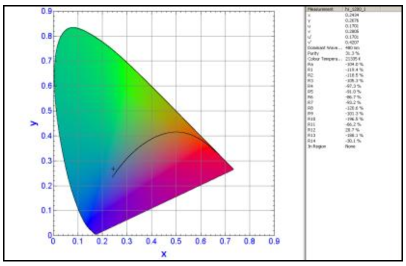
View spectral data/ marker list/ measurements: Presents to right of spectrum window spectrum values, markers and calculated measurement values (spectral integrals).

6. CIE diagram view

View/ CIE diagram

6.1 Introduction

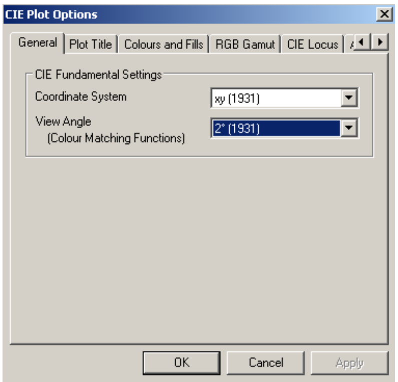
Active when measurements are performed over the entire photopic region, 380-780nm, this view calculates the colorimetry of a given spectral shape, indicated on a CIE diagram. Colorimetry parameter values are returned in a table to the right of the graphic.



This view can be set as default in the ***Tools/ Options*** window, select "Automatically show CIE diagram after scan".

6.2 CIE diagram Settings

This window can be accessed via pushing the right mouse button whilst the cursor is over the CIE diagram.



Options are as follows.

General: Set the coordinate system and viewing angle to be used when plotting the CIE diagram.

Plot Title: Apply or not title to graph, edit text properties.

Colour and Fill Settings: Set the colour for the background of the CIE diagram. The fill type of the diagram is also selectable - the default being RGB Colours. A gamma correction function can also be applied to take account of the brightness characteristics of the display monitor. The default setting is to use gamma correction with a typical value of 1.6.

RGB Gamut Settings: The RGB colour system used to fill the CIE diagram can be set. The settings depend on the monitor being used. If the Fill RGB Gamut Only checkbox is selected then only those colours reproducible on a computer monitor will be displayed. A locus can be drawn around this RGB gamut. The line style of the locus is user-defined.

CIE Locus Settings: This page sets the style of the locus around the CIE diagram. Wavelength markers can also be The text and font settings of the markers can be adjusted.

Axis Title Settings: Select whether to show each of the x and y-axis titles, defining font settings.

Axis Settings: Set which axes are shown and which colour to use. The data ranges can also be set, although the displayed region can also be set by the zoom function.

Axis Tick Settings: Set the style of the ticks axis ticks.

Grid Line Settings: show/ not major and minor grid lines on each of the axes, defining colour and style. The colour and style of the major and minor lines can be set.

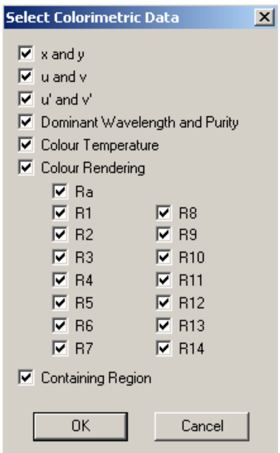
6.3 Set colorimetric data

Analysis/ Set colorimetric data

Define which parameters should be reported with the CIE diagram.

Options are:-

•Colorimetric data in different coordinate systems
•Dominant wavelength and purity
•Colour temperature
•Colour rendering
•Containing Region (see next section)



6.4 CIE Colour Regions

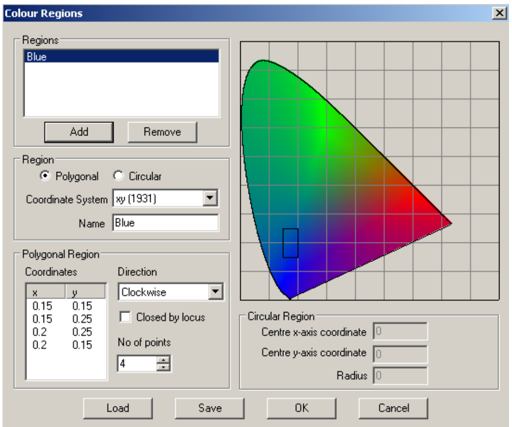
Analysis/ Set colour regions

Specific colour regions of interest may be defined an named, such that, having finished a scan, Benwin+ might, in the CIE diagram view report in which, if any, region a given source falls. The procedure for defining regions is as follows.

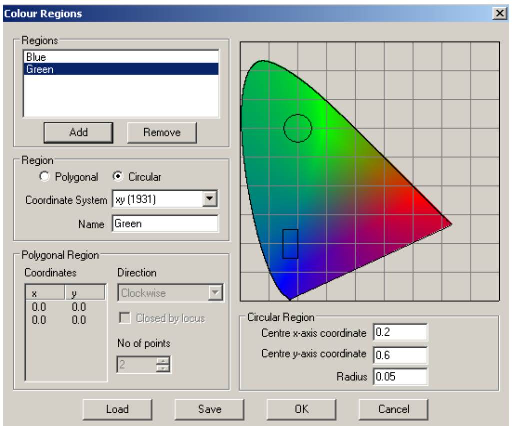
•Choose Polygon or Circular
•Define co-ordinate system
•Type in name

For polygon:-

•Define direction
•Define number of points
•Double click on x and y values in table to edit
•Hit add to accept



For circular:-
•Define x and y co-ordinates
•Define Radius
•Hit add to accept



A group of regions may be saved, and loaded as appropriate.

Having performed a scan, and presuming that containing region is selected in set colorimetric data, the region in which lies a measurement data point shall be reported.

6.5 Further features

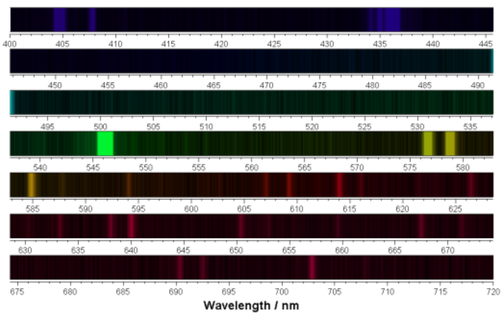
In a similar manner to the spectrum view, one may zoom into specific regions using left mouse click and drag to define region of interest.

Right mouse click gives access to changing the settings and defining colour regions.

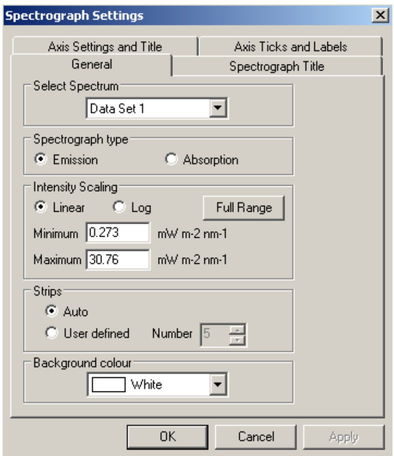
7. Spectrograph view

View/ Spectrograph

Of use when measuring line sources, the spectrograph view presents a line spectrum view of source spectral features.



Right mouse click over the spectrograph gives access to properties.



General: Define spectrum as being emission or absorption type, apply linear/ logarithmic scale, define scale, range, and number of bars in spectrograph.

Axis settings & title: Define axis and fonts

Axis ticks and labels: Define ticks, labels and fonts

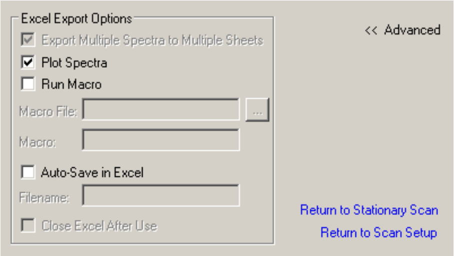
Spectrograph title: Add title, defining style.

8. Export to Excel

It is possible to export scan results to Excel, either at the end of a scan or via the scan menu.

Via the post-scan page

In advanced>>, one can edit the Excel export settings.



Having performed multiple scans in one window, the Export Multiple spectra to multiple sheets button becomes active. This permits the choice of exporting each spectrum to an individual worksheet, or placing all in one worksheet.
One may choose whether or not to plot the spectrum on exporting to Excel.
Should a macro be required, select “Run macro” to run pre-defined macro (see appendix 2 for information on writing macros). Define the macro file using the “…” button to select, and define the name of the required macro
One may choose to autosave in Excel, in which case a filename is required.

Else, one can export via

File/ Export/ Export to Excel

9. Use of Benwin+ on Desk Computers

It is possible to install Benwin+ on a desktop computer to view measurement results extra-laboratory.

•Load Benwin software CD into computer.
•Double click on the set-up launcher icon, which shall take you through the set-up process.
•You may now run Benwin+ for use to load saved spectra etc.
•Initialising will not however work

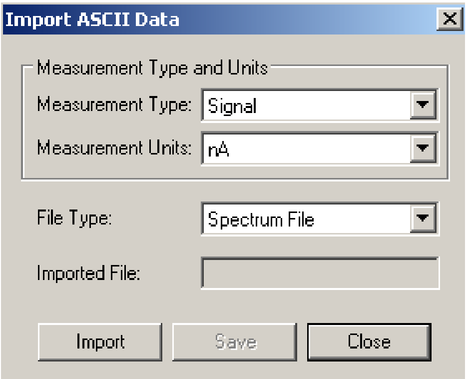
10. Menu reference

The following is a reference of those Benwin+ specific menu items.

10.1 File

An expanded menu is available when a spectrum opened.

Import Ascii data: Import ascii two-column ascii file wavelength in left column, values in right, for preparation as Benwin+ spectrum, certificate or calibration file.



Using pull down menus, define measurement type, units and file type.

File types are:-

*.ben- Benwin+ spectrum file
*.bcf- Benwin certificate file. When applying data correction, the certificate file must be in this format (see § 4.4)

Import Colorimetry data: Import **

Export to Ascii: Export spectral results to two-column ascii file (*.dat)

Benwin+1.0 file:- Benwin+ spectrum files contains not only spectral file information, but colorimetry, dark current, integral values etc. Now, Benwin+ 2.0 saves files in binary format, version 1.0 in Ascii format. Export to version 1.0 file to extract required values in ascii format.

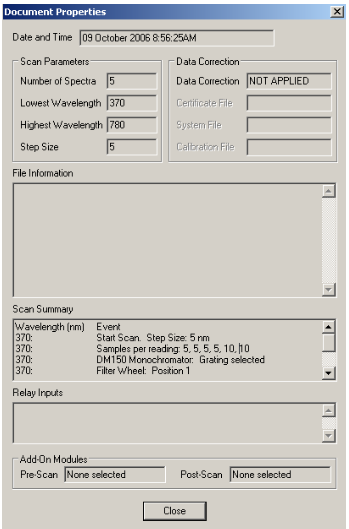
Export to Excel: Export spectral results to Excel, see §8

Graphics File: Export graph in a number of image formats. Having chosen file name and format, the user is then presented with a window to define resolution.

Measurements to ascii: Where spectral integrals of an add-on processes further the spectral data, this permits exporting these values to ascii

Copy: Copy spectral values or measurements, (integrals/ add-on values) to paste as text.

Properties: Provides details of spectral measurement, including spectral range, correction factors, file information and summary of scan events.



10.2 Scan

Scan setup: See §4.3

Signal setup: See §4.8

Stationary scan setup: See §4.7

Signal monitor: See §4.9

Set averaging: short-cut to Instruments/ ADC page See §3.2

Scan summary: Provides a summary of actions performed by the system over the defined spectral range in scan setup page.

Data correction: See §4.4

Reference setup: See §4.6

Add-on modules: See §4.11

Auxiliary measurements: See §4.12

Set file information: See §4.10

Use file information: See §4.10

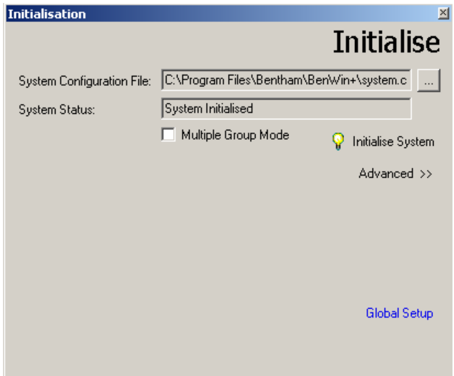
New scan: Initiate new scan in a new scan window, given scan parameters in scan setup page.

Add scan: Initiate new scan given scan parameters in scan setup page, adding scan to active spectrum window.

10.3 Tools

Initialise: See §4.2

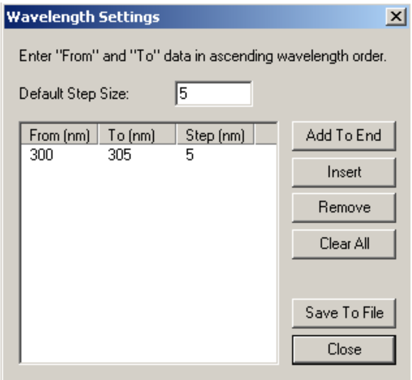
Advanced Initialisation: The standard initialise button establishes communication with hardware based on a default system.cfg file (or the latest *.cfg file used on the computer). The advanced initialisation page permits definition in the first place of a specific *.cfg file to employ.



Here can also be defined instrument group set ups and mode of operation.

It is for example possible to define two groups of detection electronics, operated in ratiometer mode, or a wavelength switched system permitting for example the use of DC electronics in the ultraviolet/ visible spectral regions, and AC electronics in the infra-red.

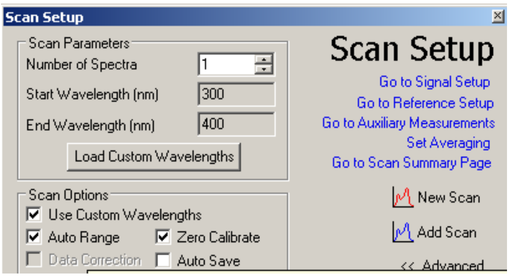
Create custom wavelength file: When measuring for example a line source, rather than performing scans over the entire spectral range, full of barren land, it is possible to define a custom wavelength file limiting scans only to those regions of interest.



One can define a default step size, start and stop ranges, and add, insert or remove as appropriate.

Having defined a custom wavelength file, save.

This file might be implemented going to scan/ scan set up and in advanced>> selecting "use custom wavelengths" and hitting the "load custom wavelengths" button to select the appropriate file.

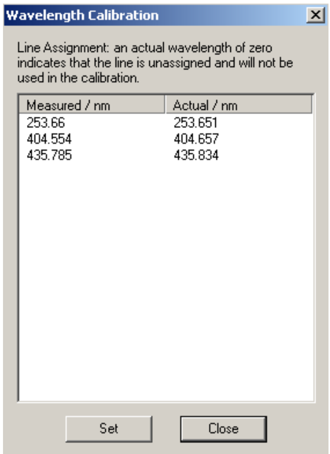


Wavelength calibration: This applies only to DMc150 and M300 monochromators having a stepping motor driven sine- bar mechanism moving the diffraction gratings, and permits ensuring that the device is correctly wavelength calibrated.

A mercury lamp is often used as a standard, although other sources may be used. Please see Appendix 1 for further information.

The procedure follows.

•Acquire a spectrum from the standard source (uncorrected is sufficient)
•Use the peak pick function on the spectrum or add peak markers to the peaks you want to use in the calibration
•Select ***Tools/ Wavelength Calibration/ Set calibration***



This dialog has two columns of peak data, the first column contains the peak data from the peak picked spectrum, the second contains the known peak positions of the source. The difference between the two is used to calibrate subsequent spectra.

By default, BenWin+ contains calibration data for a mercury emission source. Any actual wavelength values may be modified by highlighting and entering a new value. Setting to zero indicates that the line is unassigned and will not be used in the calibration.

Selecting Set opens a save dialog box and prompts for a filename for the calibration file. Calibration files are of the type *.wlc and by default are stored in ..\BenWin+\Calibration.

These ASCII files contain three columns of data and can be modified by hand. The data stored is measured wavelength, actual wavelength and wavelength difference. It is the difference in wavelength that is used to ensure accurate instrument calibration.

After setting up a calibration file, the default option is to use the file - this is indicated by a tick next to the Use Calibration command in the Wavelength Calibration sub-menu.

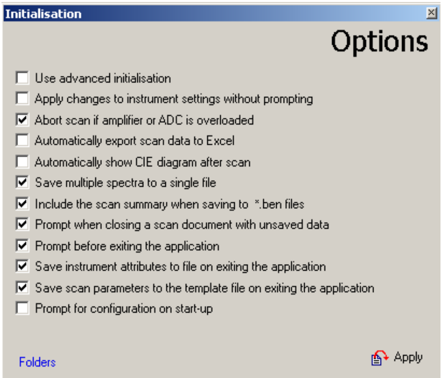
Use Calibration can be toggled on and off by clicking on the command.

A previously saved calibration file can be loaded and used by selecting Load Calibration from the Wavelength Calibration sub-menu.

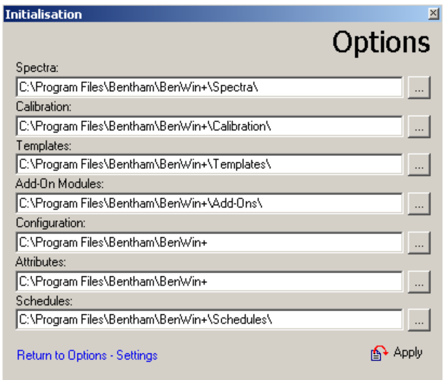
Configure schedule: See §4.5

Schedule mode: See §4.5

Options: Relates to specific operation options of Benwin+. Certain recommended items are pre-selected.



The default file locations may be modified by following the Folder link bottom left and use the "…" button to navigate to new folder location.



Configurations: See §3.8

Write to log file: Writes to log file for troubleshooting.

10.4 Analysis

Set spectrum names: See §5.2

Overlay spectra: See §5.3

Delete spectra: See §5.4

Interpolate: See §5.5

Cut: See §5.6

Concatenate: See §5.7

Invert: See §5.8

Normalise: See §5.9

Spectral arithmetic: See §5.10

Spectral average: See §5.3.1

Quantum efficiency: See §5.12

Peak picker: See §5.13

Select colorimetric data: See §6.3

Clear colour regions: See §6.4

Set colour regions: See §6.4

Update colour regions: See §6.4

Set spectral integral: See §5.14

Calculate spectral integrals: See §5.14

Calculate add-on measurements: See §4.11

10.5 View

Spectrum: See §5

CIE diagram: See §6

Spectrograph: See §7

Spectral data: Hit this button to present the numerical spectral data to the right of the spectrum window.

Marker list: Shows presently set markers in right hand list.

Measurements: Shows spectral integral results in right hand list.

Vertical split: Position spectral data/ measurements etc window to right of spectrum window.

Horizontal split: Position spectral data/ measurements etc window under spectrum window.

Wavelength colours: §5.16

Cursors: See §5.15

Markers: §5.15

Toolbars: Toolbars are as follows.

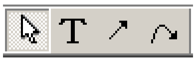
Hardware

Initialise/ Configuration

Main

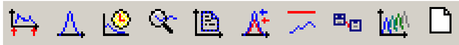
Open/ Save/ Copy spectral data/Print/ Help

Mouse Mode



Cursor/ Add text/ Draw straight arrow/ Draw curved arrow

Scan

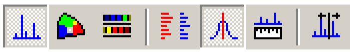


Scan setup/ signal setup/ stationary scan setup/ Signal monitor/ Scan summary/ Data corrections/ Set reference/ Add-on modules/ Set averaging/ New scan

Analysis

Peak picker/ Spectral integrals/ Set spectrum names/Overlay spectra/ Normalise

View



Spectrum view/ CIE diagram/ Spectrograph/ Spectral data/ Marker list/ Measurements/ Cursors

Status bar: Lower screen status bar showing hardware mode, system status, current wavelength and dial reading.

Show auxiliary measurements: where a system is taking auxiliary measurements select to present/ not the auxiliary measurement results (see See §4.12).

Appendix 1: Verification of Monochromator Wavelength Calibration

Wavelength calibration is usually checked using a mercury lamp the output of which consists of discrete lines at defined wavelengths. The presence of mercury in overhead fluorescent tubes can act as a good replacement for a specific lamp.

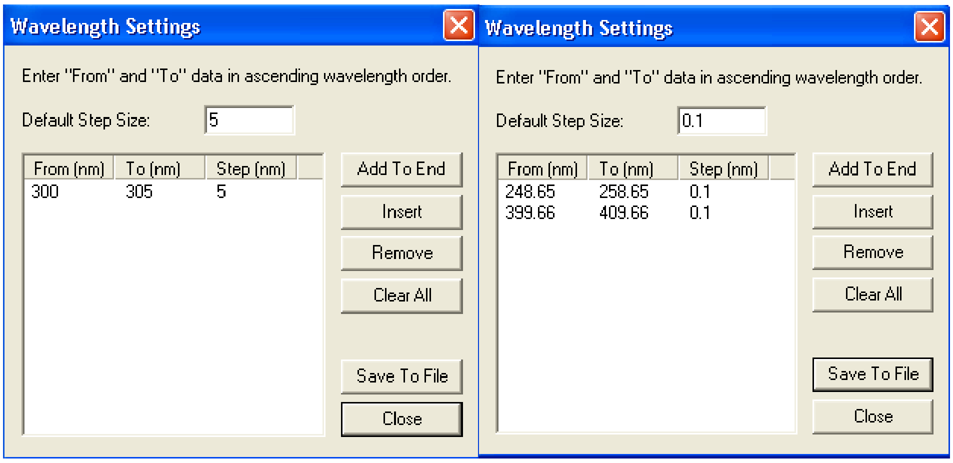
The following table shows the position of the mercury lines. Those marked in red are particularly strong lines, leading therefore to higher orders with a measureable contribution.

1st Order	2nd Order	3rd Order	4th Order	5th Order	6th Order	7th Order
184.91						
194.17						
226.22						
237.83						
248.2						
253.65	507.3	760.95	1014.6	1268.25	1521.9	1775.55
265.2						
280.35						
289.36						
296.73						
302.15						
312.57	625.14	937.71	1250.28	1562.85		
313.17						
334.15						
365.02	730.04	1095.06	1460.08	1825.1		
365.44						
366.33						
404.66	809.32	1213.98	1618.64			
407.78						
434.75						
435.84	871.68	1307.52	1743.36			
491.6						
496.03						
546.07	1092.14	1638.21				
576.96						
579.07						
690.7						
1013.98						

It is of course important to ensure that whilst observing the higher order lines, the order sorting filters of the monochromator are de-activated. This is done by going to instruments/ filter wheel and resetting the true insertion wavelengths with 0nm.

Use the tools/ create custom wavelength file facility of Benwin+ to define a scan around desired emission lines rather than scanning over the full range.

Go to tools/ create custom wavelength file, to view the following, left.



Set default step size, insert the number of lines required, double click on values to edit and finally save to file.

Choose a step size of minimum 0.15nm to view lines.

Scans using this file are initiated by going to scan/ scan set, select custom wavelength file and load file required, then scan as normal.

Please be aware of the slits presently in system. Having for example 5nm slits present and looking at the lines around 365nm, one will effectively see several lines which can distort the result and wrongly show lack of calibration.

Appendix 2: Excel Macros

1. Create a macro in Excel on some data that has been exported from BenWin+.
2. The wavelength data are exported to cells A3 to An depending on the number of points in the spectrum. The intensity data are exported to cells B3 to Xn depending on both the number of points and the number of spectra in the file. Row 2 contains column titles.
3. In Excel, click on the Tools menu, then on the Macro sub-menu and finally on the Macros command.
4. Select the name of the previously created macro and click on the Edit button to open the Visual Basic macro editor.
5. The 1st line of the macro function will be: Sub MacroName(). BenWin+ sends a number of useful parameters to the macro function. The macro will need to use some of these parameters. The parameters in order are:

Parameter	**Description**
strWorkBookName	A string containing the name of the workbook that contains the spectrum data.
strWorkSheetName	A string containing the name of the worksheet that contains the spectrum data.
nNoOfPoints	An integer containing the number of spectrum data points in the first spectrum.
nNoOfSpectra	An integer containing the number of exported spectra.
dblStepSize	A double value containing the stepsize between each spectrum point.
strWavelengthDataRange	A string containing the cells that contain the wavelength data e.g. "A3:A103".
strSpectraDataRange	A string containing the cells that contain the intensity data e.g. "B3:D103".

The 1st line of the macro should be changed to include all these parameters:
Sub MacroName(strWorkBookName, strWorkSheetName, nNoOfPoints, nNoOfSpectra, dblStepSize, strWavelengthDataRange, strSpectraDataRange)

6. At any point in the macro, if any of the above parameters is referred to explicitly then the explicit name should be changed to the variable name. As an example consider the alterations made to the Anvis_Calculator macro (see below). In this example, '"Book1"' has been changed to 'strWorkBookName', '"B2:B112"' has been changed to ‘strSpectraDataRange' etc. (Some additional unnecessary processes made using the mouse have also been removed in the new version.) The parameter changes must be made because if several Excel workbooks are already open then the workbook used to hold the freshly exported data will not be 'Book1' but a higher book number instead.

Notes:

1. After the parameters have been added to the first line of the macro, the macro name will not be visible under the Tools | Macro | Macros dialog box. To make further changes to a macro in this state use the menu option Tools | Macro | Visual Basic Editor. This will open the same editor as used above and the macro should be located in the project explorer under the project name, in one of the associated modules.
2. The file name of the Excel workbook that contains the macros should not contain any spaces.

Example

Original Macro

```
Sub Macro1()
'
' Macro1 Macro
' Macro recorded 04/12/01 by gah
'
'
```

```
    Windows("Book1").Activate
    Range("B2:B111").Select
    ActiveWindow.ScrollRow = 1
    Range("B2:B112").Select
    Application.CutCopyMode = False
    Selection.Copy
    Windows("Anvis_calculator.xls").Activate
    Range("B2").Select
    ActiveSheet.Paste
    Range("I2:K11").Select
    Application.CutCopyMode = False
    Selection.Copy
    Windows("Book1").Activate
    Range("D23").Select
    Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone, SkipBlanks:= _
        False, Transpose:=False
    Range("D23").Select
    Selection.PasteSpecial Paste:=xlFormats, Operation:=xlNone, SkipBlanks:= _
        False, Transpose:=False
    Range("H23").Select
End Sub
```

Modified Macro

```
Sub Macro1(strWorkBookName, strWorksheetName, nNoOfPoints, nNoOfSpectra, dblStepsize, strWavelengthDataRange, strSpectraDataRange)
'
' Macro1 Macro
' Macro recorded 04/12/01 by gah
'
'
    Windows(strWorkBookName).Activate
    Sheets(strWorksheetName).Select
    Range(strSpectraDataRange).Select
    Application.CutCopyMode = False
    Selection.Copy
    Windows("Anvis_calculator_updated.xls").Activate
    Range("B2").Select
    ActiveSheet.Paste
    Range("I2:K11").Select
    Application.CutCopyMode = False
    Selection.Copy
    Windows(strWorkBookName).Activate
    Sheets(strWorksheetName).Select
    Range("D23").Select
    Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone, SkipBlanks:= _
        False, Transpose:=False
    Range("D23").Select
    Selection.PasteSpecial Paste:=xlFormats, Operation:=xlNone, SkipBlanks:= _
        False, Transpose:=False
End Sub
```

Appendix 3: Add-on modules

Introduction

The BenWin++ application has been designed to be readily user customisable. Often the requirement is to integrate non-Bentham instruments into the set-up. Examples of this are moving a translator before each scan or taking a measurement from a digital voltmeter. Other scenarios are to select scan parameters through a custom user interface or to perform post-processing of the spectrum after acquisition. This has been achieved by using add-on dynamic link libraries (DLLs) with a known interface of exported functions.

General Programming Points

Calling Convention

All functions use the cdecl calling convention and must be declared as:

```
extern "C" __declspec(dllexport)
```

Integer Types

The add-on DLL interface uses the data types for 32-bit Windows operating systems. Thus an int is 4 bytes long.

Return Values

All the DLL functions return an HRESULT. An HRESULT is a 32-bit integer which contains error information. The different standard values for an HRESULT are defined in winerror.h. The writer of add-on modules only needs to be concerned with three values:

```
#define S_OK 0x00000000L

#define E_FAIL 0x80000008L

#define E_NOTIMPL 0x80000001L
```

The first of these is the success code and the second is the generic error code. These should be returned from functions to indicate whether an error occurred. The last error code should be returned from functions that the DLL does not implement. Which functions must be implemented and which are optional are described below.

Information and Configuration Functions

This section describes functions which are used for retrieving information from the DLL and for setting up its parameters. All except for DisplaySetupDialog must be implemented.

HRESULT GetDLLDescription(char* Description, int NoOfChars);

```
HRESULT GetInformationString(char* Description, int NoOfChars);

HRESULT DisplaySetupDialog(HINSTANCE hSDKInst,
                           HWND hWnd,
                           int* NoOfSpectra,
                           double* StartWavelength,
                           double* EndWavelength,
                           double* StepSize,
                           int* AutoRange,
                           int* ZeroCalibrate,
                           int* ApplyDataCorrection,
                           int* AutoSave,
                           char* FileName,
                           int* FileNumber,
                           int* ReturnToStartWavelength,
                           int* CloseShutter,
                           int* AdaptiveIntegration,
                           int* Averages);
```

Get DLL Description

This is to return a text string describing the DLL, for example “Translator control” or “Temperature measurement”. The character array passed from BenWin+ is 1024 characters long so the description must not be longer than this.

Get Information String

This function should return a text string describing the DLL’s current status, for example “Voltage = 5.27 V”. The character array passed from BenWin+ is 1024 characters long and the information string must be no greater than this length.

Display Set-Up Dialog

This function is for displaying a dialog box through which the user can configure the DLL settings. For example a translator control DLL might allow the user to set starting and final positions and a delay to wait for after every move. The function is passed all the scan setup information from BenWin+ so that it can respond to these settings and change any values that need to be altered. The parameters are described below.

Parameter	**Description**
hSDKInst	The HINSTANCE of the loaded Bentham SDK. From this GetProcAddress() can be used to obtain function pointers. This allows the add-on to interact with the main instrument set-up.
hWnd	A window handle to the window that will be the parent to the configuration dialog.
NoOfSpectra	The number of spectra to be acquired.
StartWavelength	The starting wavelength in nm.
EndWavelength	The end wavelength in nm.
StepSize	The scan step size in nm.
AutoRange	Whether to autorange the amplifier during the scan: 1 for autorange and 0 for no autorange.
ZeroCalibrate	Whether to zero calibrate before the scan: 1 to zero calibrate and 0 to skip.
ApplyDataCorrection	Whether to apply data correction: 1 to do so and 0 to skip.
AutoSave	Whether to autosave the spectrum after the scan: 1 to autosave, 0 to not.
FileName	A 256 character string containing the root for the names of autosaved files.
FileNumber	A 256 character string containing the root for the names of autosaved files.
ReturnToStartWavelength	Whether to return to the starting wavelength after the scan: 1 to do so, 0 to stop at the final wavelength.
CloseShutter	Whether to close the shutter after the scan: 1 to close the shutter and 0 to leave it open.
AdaptiveIntegration	Whether to use adaptive integration, 1 to do so and 0 to use the same number of averages regardless of the amplifier range.
Averages	An array of seven integers containing the number of averages. Averages[0] is the value when not using adaptive integration. Averages[1] to Averages[6] are the values for each amplifier range from the least sensitive to the most sensitive.

Measurement and Control Functions

The functions described in this section are used to take measurements and to trigger operations by the DLL. These are:

HRESULT GetNoOfStartMeasurements(int* NoOfMeasurements);

HRESULT GetStartMeasurements(HINSTANCE hSDKInst,

double* Measurements,

```
                        int NoOfMeasurements,
                        int Spectrum);
HRESULT GetNoOfEndMeasurements(int* NoOfMeasurements);
HRESULT GetEndMeasurements(HINSTANCE hSDKInst,
                       double* XData,
                       double* YData,
                       int Spectrum,
                       int NoOfPoints,
                       int NoOfMeasurements,
                       double* Measurements);
HRESULT PerformStartAction(HINSTANCE hSDKInst,
                       HWND hWnd,
                       int Spectrum,
                       int* NoOfSpectra,
                       double* StartWavelength,
                       double* EndWavelength,
                       double* StepSize,
                       int* AutoRange,
                       int* ZeroCalibrate,
                       int* ApplyDataCorrection,
                       int* AutoSave,
                       char* FileName,
                       int* FileNumber,
                       int* ReturnToStartWavelength,
                       int* CloseShutter,
                       int* AdaptiveIntegration
                       int* Averages);
```

```
HRESULT PerformEndAction(HINSTANCE hSDKInst,
                         HWND hWnd,
                         double* XData,
                         double* YData,
                         int Spectrum,
                         int NoOfPoints);
```

In BenWin+ the user can select a DLL to be called at the start of each spectrum and another to be called after the scan. This is described further below. A single DLL can be simultaneously selected in both roles. The functions fall into two pairs: a set called at the start of the spectrum and another at the end. The table below indicates which functions are called for each of the selected DLLs.

Function	Relevant DLL
GetNoOfStartMeasurements	Pre-Scan DLL
GetStartMeasurements	Pre-Scan DLL
GetNoOfEndMeasurements	Post-Scan DLL
GetEndMeasurements	Post-Scan DLL
PerformStartAction	Pre-Scan DLL
PerformEndAction	Post-Scan DLL

Get Number of Start Measurements

This function must return the number of data values that the DLL supplies when GetStartMeasurements() is called. This is required to enable BenWin+ to create an array of the correct size. A module which does not take any start measurements should return zero through this function.

Get Start Measurements

This function is called at the start of spectra when a pre-scan DLL has been selected when the number of start measurements is greater than zero. The pre-scan DLL can be set to be called for each spectrum in the scan, for only the first, or for all but the first (see below). When this function is called the DLL is passed a handle to the Bentham SDK, an array of double values (8 byte floating point), the number of measurements BenWin+ is expecting and the number of the current spectrum. The number of measurements will match the value returned by GetNoOfStartMeasurements() and gives the size of the array. If the value is incorrect, the DLL should return an error. The spectrum number is zero-based. Thus for a scan of five spectra where the pre-scan DLL is to be called for each spectrum the function will be called with the spectrum number set to 0, 1, 2, 3 and 4 respectively. A DLL which does not supply any pre-scan measurements should return E_NOTIMPL from this function.

Get Number of End Measurements

This function must return the number of data values that the DLL provides when GetEndMeasurements() is called. This is so that BenWin+ can create an array of the correct size. A module which does not take any end measurements should return zero.

Get End Measurements

This function is called following acquisition of spectra when a post-scan DLL has been selected. As described in Section 5, this can be for all spectra, only the last spectrum, or for all but the last spectrum. The parameters passed to the function are described below.

Parameter	Description
hSDKInst	The HINSTANCE of the loaded Bentham SDK. From this GetProcAddress() can be used to obtain function pointers. This allows the add-on to interact with the main instrument set-up.
XData	The x data set for the spectrum that has just been completed. This is an array of doubles with the number of elements equal to NoOfPoints.
YData	The y data set for the spectrum that has just been completed. This is an array of doubles with the number of elements equal to NoOfPoints.
Spectrum	The spectrum number of the spectrum. This is zero-based.
NoOfPoints	The number of points in the spectrum. This gives the size of the data arrays.
NoOfMeasurements	The number of measurements BenWin+ is expecting to be set by the DLL. This value has previously been obtained by calling GetNoOfEndMeasurements().
Measurements	An array of doubles with the number of elements equal to NoOfMeasurements. The DLL should set the values.

A DLL which does not supply any post-scan measurements should return E_NOTIMPL. The function is passed the spectrum data so the DLL can make measurements from the spectrum itself, e.g. integrating between two wavelengths, instead of or in addition to reading values from an instrument.

Perform Start Action

This function is called at the start of spectra when a pre-scan DLL has been selected. The parameters passed to the function other than the third argument are the same as those for the DisplaySetupDialog() function and are described in the table for that function. The third argument is the spectrum number of the spectrum about to be acquired. This is zero-based.

The function receives the full set of scan setup parameters and can change their values if required. However, the number of spectra, the start and end wavelengths and the step size cannot be changed on any other than the first spectrum of a scan. Any changes to these parameters on subsequent spectra will be ignored by BenWin+. When this function is called the DLL should take any necessary action. Examples are moving translators to the required position or waiting for a trigger. The function should not return until the action is completed. For example if the DLL moves translators then it should not return until they have completed their motion. A DLL that does not support this function should return E_NOTIMPL.

Perform End Action

This function is called after the current spectrum has been acquired. It is passed the spectral data, a DLL handle and a windows handle as described below.

Parameter	**Description**
hSDKInst	The HINSTANCE of the loaded Bentham SDK. From this GetProcAddress() can be used to obtain function pointers. This allows the add-on to interact with the main instrument set-up.
hWnd	A windows handle from BenWin+ that the DLL should use if it needs to display any windows.
XData	The x data set for the spectrum that has just been completed. This is an array of doubles with the number of elements equal to NoOfPoints.
YData	The y data set for the spectrum that has just been completed. This is an array of doubles with the number of elements equal to NoOfPoints.
Spectrum	The spectrum number of the spectrum. This is zero-based.
NoOfPoints	The number of points in the spectrum. This gives the size of the data arrays.

This function can be used to perform an operation using external equipment, for example switching off a light source. Alternatively it can be used to perform some data processing on the spectrum.