

UV/Vis/NIR Spectroscopy

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Characterization of Custom Light Sources using the LAMBDA 650/750/850/950/1050 UV/Vis and UV/Vis/NIR Research Spectrometers

Introduction

Although UV/Vis and UV/Vis/NIR spectrophotometers from PerkinElmer come equipped with their own light sources —

a tungsten-halogen visible lamp and a deuterium ultraviolet lamp — often there is a research need to characterize the spectral energy profile of custom light sources. This experiment normally requires the user to deactivate and remove the standard light sources of the spectrometer, and substitute the custom light source being studied in the vacated lamp area. These light sources can exist in many forms, from lasers, LED's, architectural light sources, broad continuum high-pressure arc lamps, low-pressure discharge lamps, etc. Not only is the relative power of a lamp important, but also the energy profile as a function of wavelength.



The PerkinElmer LAMBDA™ 650/750/850 UV/Vis and the LAMBDA 950/1050 UV/Vis/NIR research spectrophotometers are ideal systems for the characterization of custom light sources. Not only are these instruments true double monochromator spectrometers, which provide artifact-free spectra, but with little effort, these spectrometers can be modified to allow adaptation to most custom light sources. The design of these instruments facilitates this in two ways – first, the lamp compartment area can be accessed externally without the need to lift the main instrument cover, and second, these spectrometers are the only available commercial systems to offer completely removable source compartments. The normal interference of the default lamps, lamp hardware and cabling to the proper placement of a custom light source can be eliminated. Equally as important, the UV WinLab™ Version 6 software that controls these spectrometers can be used to bypass the normal order-sorting filters, which is required for obtaining a true energy profile of a light source.

The purpose of this application note is to describe how custom light sources can be fitted to the LAMBDA 650/750/850/950/1050 spectrometers, and provide guidelines for creating a working method in UV Winlab Version 6 to acquire custom lamp spectra. Example spectra of different light sources will be presented.

Experimental

Designing an experiment to scan custom light sources with the LAMBDA 650/750/850/950/1050 spectrometers involves a number of steps, including the modification of the spectrometer's default hardware, and the creation of an appropriate method in the UV WinLab Version 6 software.

Step 1 - Setting Up the Hardware

The lamp compartment on the LAMBDA 650/750/850/950/1050 spectrometers is located at the top left corner of the instrument. Remove the outside cover and the internal metal light shield. The default lamp compartment will be visible as shown in Figure 1, with the major components labeled.

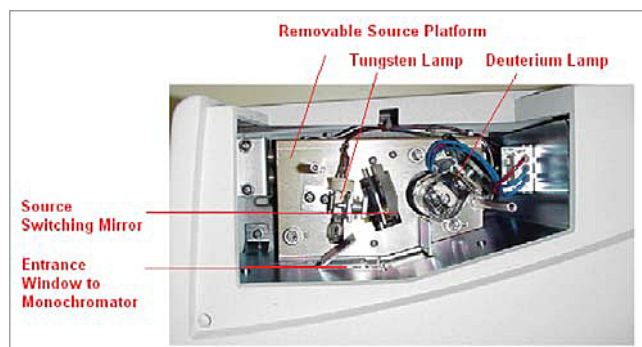


Figure 1. LAMBDA 650/850/950 source compartment.

If the light source apparatus is small enough, it may be possible to fit this in the source compartment directly by simply placing the light source in place of the deuterium lamp. To do this, turn the instrument off, let the deuterium lamp cool for at least 15 minutes, loosen the knurled nut securing the lamp bracket to the lamp post, disconnect the lamp connector, and remove the lamp. Then, position the light source in the vacated lamp area, making sure that it evenly illuminates the entrance window to the monochromator.



Figure 2. Source platform removed from instrument (rear view).



Figure 3. Close-up of vacated source compartment (rear view).

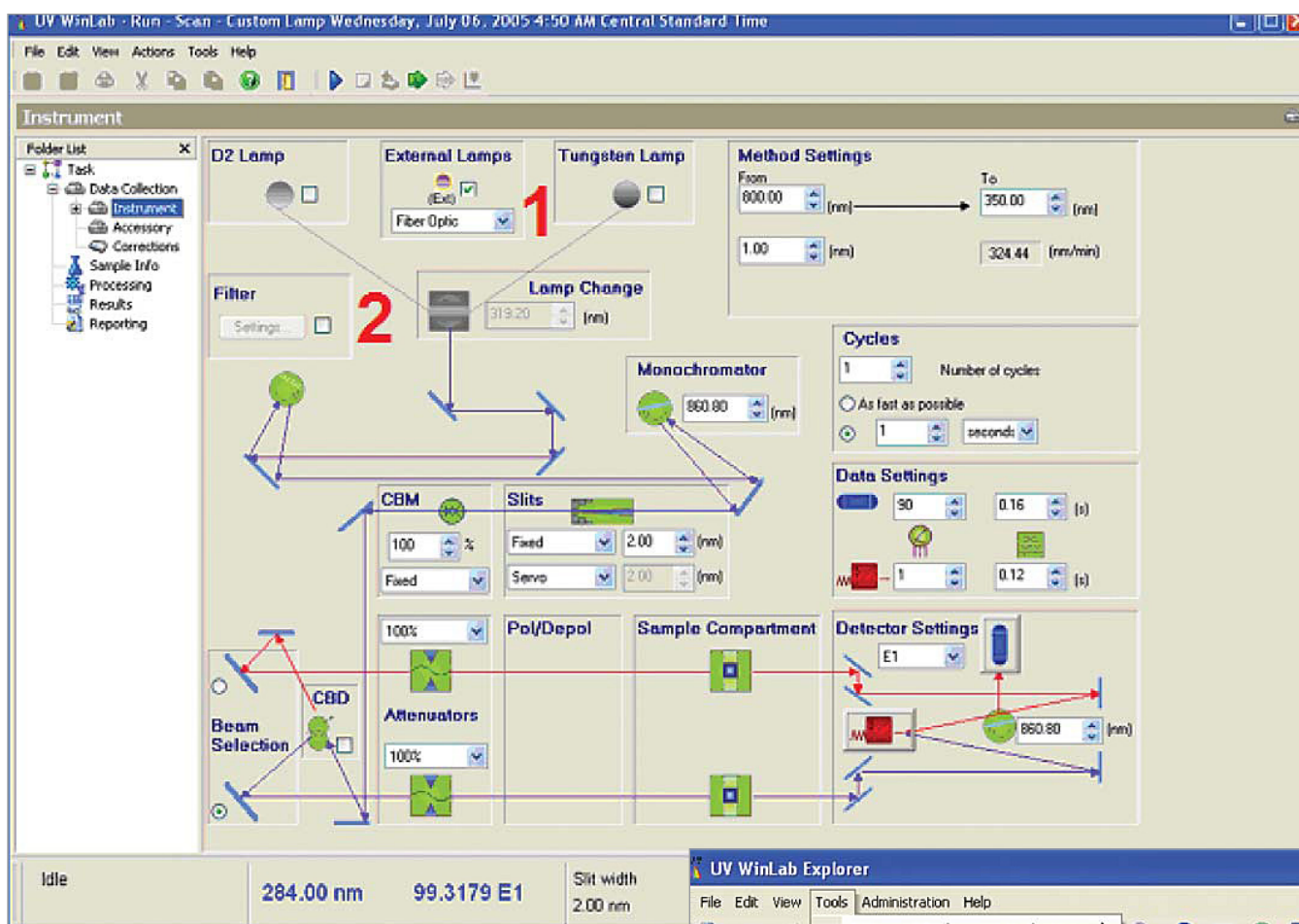


Figure 4. Instrument Parameter Page in UV WinLab Version 6.

Step 2 - Creating a Method

After the source compartment has been configured as required for the experiment and the light source positioned to fill the entrance window to the monochromator, the next step is the creation of an instrument method to allow the scanning of the energy profile of the light source.

The instrument parameters of the LAMBDA 650/750/850/950/1050 are controlled with UV WinLab Version 6. The first steps in creating a method are:

- Creating a profile for the custom light source in the Instrument Properties menu. (Note – this step is recommended, but not required).
- Editing the filter table properties to bypass the normal order-sorting filters of the spectrometer.

Creating a Custom Lamp Profile

The UV WinLab Version 6 instrument parameter page for the LAMBDA 650/750/850/950/1050 is shown in Figure 4. External lamp identifications can be programmed (this is optional) by the user so they can be selected in the External Lamps section (Labeled as #1).

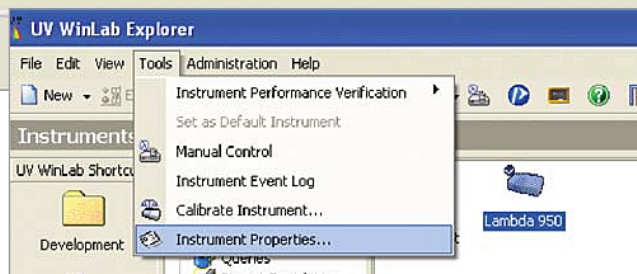


Figure 5. The Instrument Properties menu.

To program identification for a light source, right-click on the LAMBDA 650/750/850/950/1050 icon under the Instrument's menu in UV WinLab Explorer, and select Instrument Properties, as shown in Figure 5 above.

An external lamp profile can be created by adding the lamp name to the list, as shown in Figure 6.

After adding the external sources required, the appropriate light source can now be directly selected from the Instrument Method page shown in Figure 7. Make sure the default Deuterium (D2) and Tungsten lamps are off (unchecked).

Editing the Filter Table Properties

The Filter section in Figure 4 (labeled as #2) is where the spectrometer's filter table assignments can be accessed.

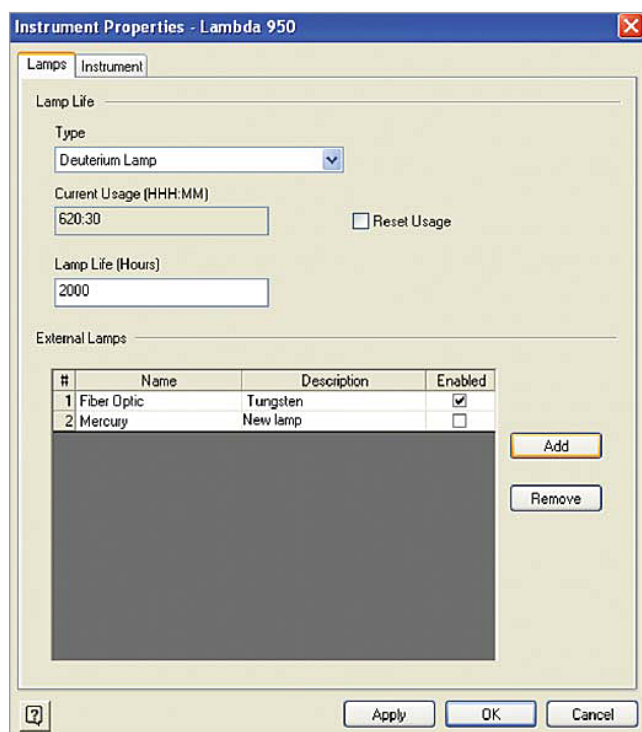


Figure 6. Adding an external lamp profile to the Instrument Lamp Properties menu.

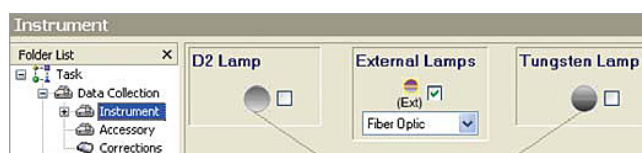


Figure 7. External Lamp menu shown on the Instrument page.

Note that the user must have Service permissions to access this area of the software. If external lamp light is passed through the double monochromator of the LAMBDA 650/750/850/950/1050, bypassing the internal ordersorting filters is important to see the true energy profile of a light source. Order sorting filters are normally used to reduce stray light in normal operation, but, unless bypassed, can create discontinuities in the energy profile. To define the filter table, click on the Filter option in the Instrument page and click on Settings. The normal sequence of the order sorting filters is shown in Figure 8.

Note that at specific wavelengths, a predefined order sorting filter will automatically be moved into the beam. If the experiment is to scan the light source in the visible spectrum, for example 800 to 300 nm, the user will be required to click on each Filter Type field between the start and end wavelengths (in this case starting with Filter #4, 810.4 nm) and change the default assignment to the selection "T=100%". This will move the filter wheel to an open (100% T) position for the entire scan. When completed, the modified filter assignment table will look similar to the parameter shown on the right side of Figure 8 for a visible range scan.

Note that the modified filter table will only affect the current method being created. The other LAMBDA 650/750/850/950/1050 methods previously created will not be affected. To reset the filter table back to the default instrument settings, click on the Defaults button shown in Figure 8.

Once the Filter table has been defined, the remaining parameters for the Custom Light Source method need to be set. The following parameters are recommended to start:

Table 1. Initial Instrument Setup Parameters

Parameter	Condition
Wavelength Start/End (nm):	800 to 300
Ordinate Mode:	E1
Integration Time (sec):	0.16
Data Interval:	1
UV/Vis Gain:	90
Slit (nm):	2

Depending on the intensity of the light source, the gain level for the detector can be adjusted in the range of 0-256 units to allow the energy profile to be scaled properly. The higher the gain numbers, the greater the detector sensitivity. In the E1 energy mode, detector saturation will occur at 100% – the gain level must be reduced to bring the highest reading in the scan below 100%. Likewise, the slit or bandpass selection will also affect the overall signal level. Light sources having sharp spectral lines often need to be scanned with narrow resolution (i.e., 0.1 nm) – in these cases the gain number will likely need to be increased. Once the initial parameters have been set, the method should then be saved under an appropriate method name (i.e., Custom Light Source).

Results

Using the protocol described in this paper, a number of light sources were scanned. Shown in Figure 9 is a higher resolution scan (0.1 nm) of a fluorescent light source. Note: any light source incorporating a glass window or enclosure will not transmit UV light. An energy spectrum of a red LED is shown in Figure 10, with the peak maximum identified on the graph. Finally, an energy spectrum of a visible enhanced grow lamp is shown in Figure 11, with the peak maximum labeled.

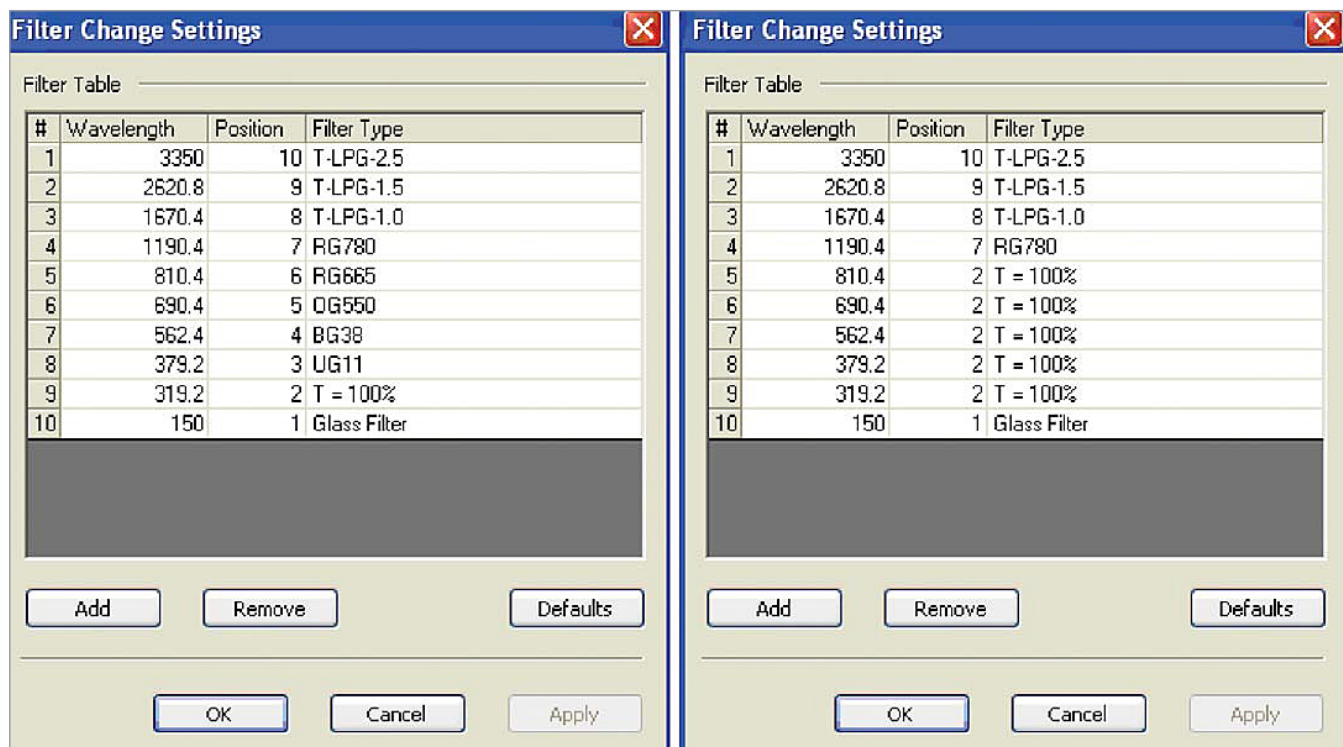


Figure 8. Default Filter Settings shown on the left side, and modified Filter Settings for Scanning a Visible Light Source on the right. Over the wavelength region scanned, the filter positions have been set to 100%T.

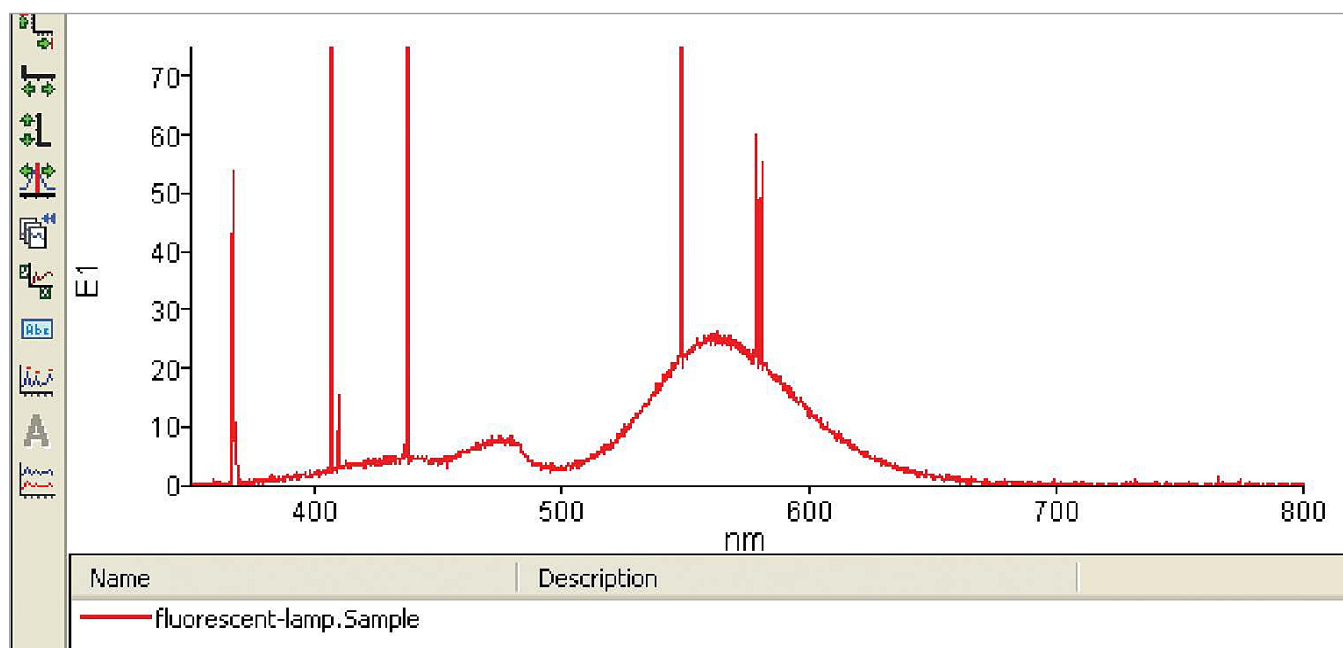


Figure 9. Energy spectrum of a fluorescent light source under high resolution.

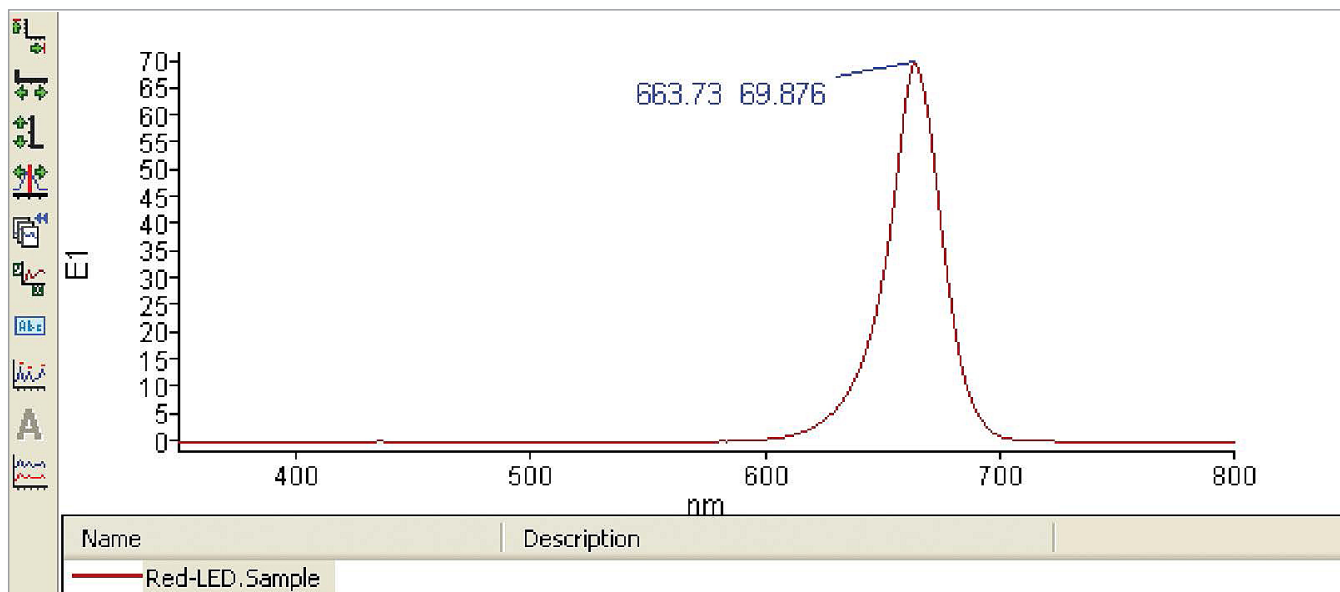


Figure 10. Energy spectrum of a red LED.

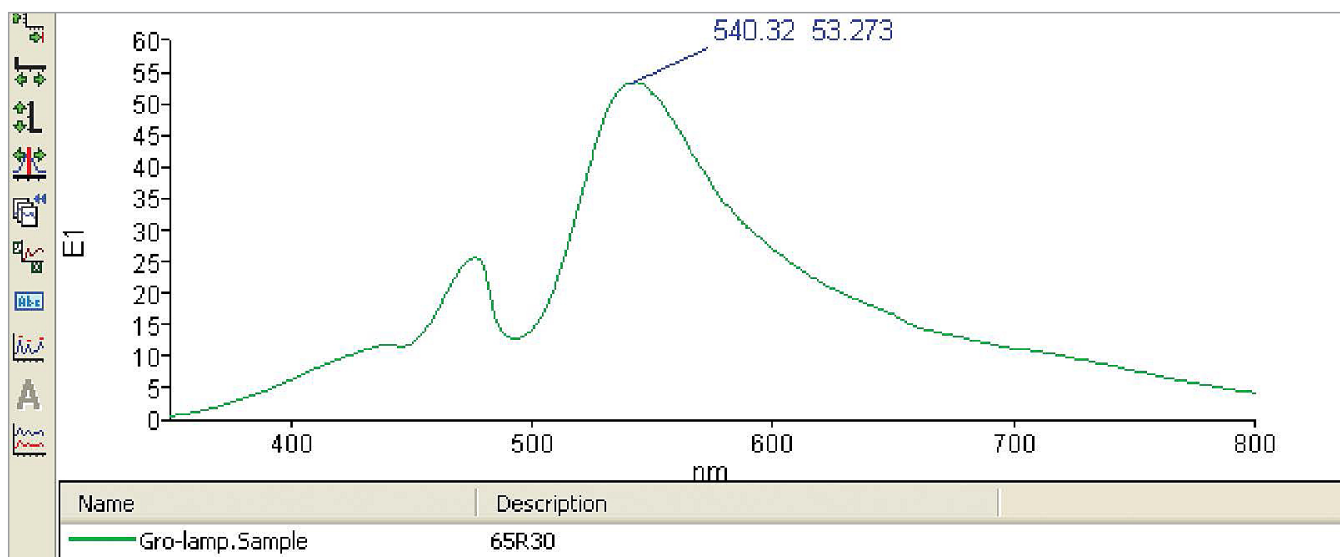


Figure 11. Energy spectrum of a visible enhanced grow lamp.

Conclusion

The PerkinElmer LAMBDA 650/750/850/950/1050 high-performance spectrometers are ideally suited for characterizing custom light sources. The removable source platform allows many types and sizes of custom lamps to be fitted easily. UV WinLab 6 software allows custom light

sources to be defined in the software, and offers direct control over the energy scan parameters. The wide gain control ensures that the profile of virtually any light source can be scaled properly. The capability to bypass the normal order sorting filters allows artifact-free energy profiles to be acquired.