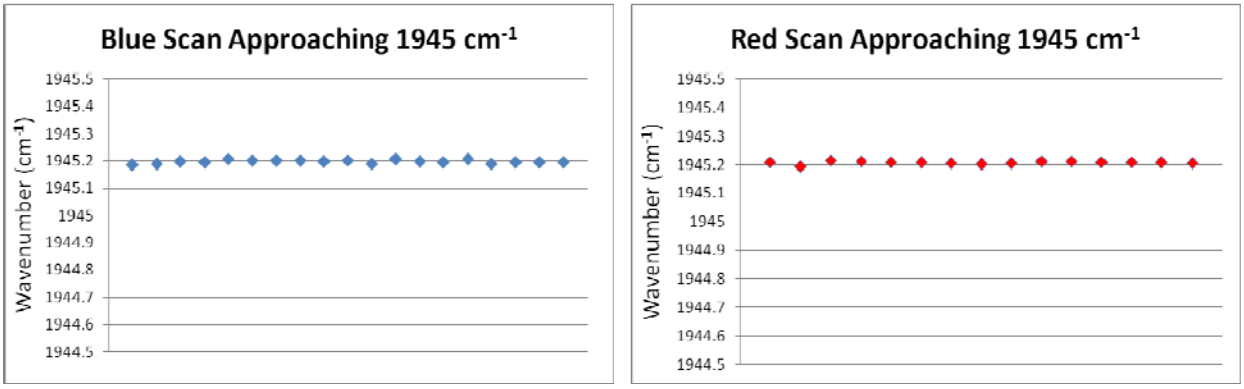
Precision & Accuracy of Daylight Solutions Mode Hop-Free Lasers

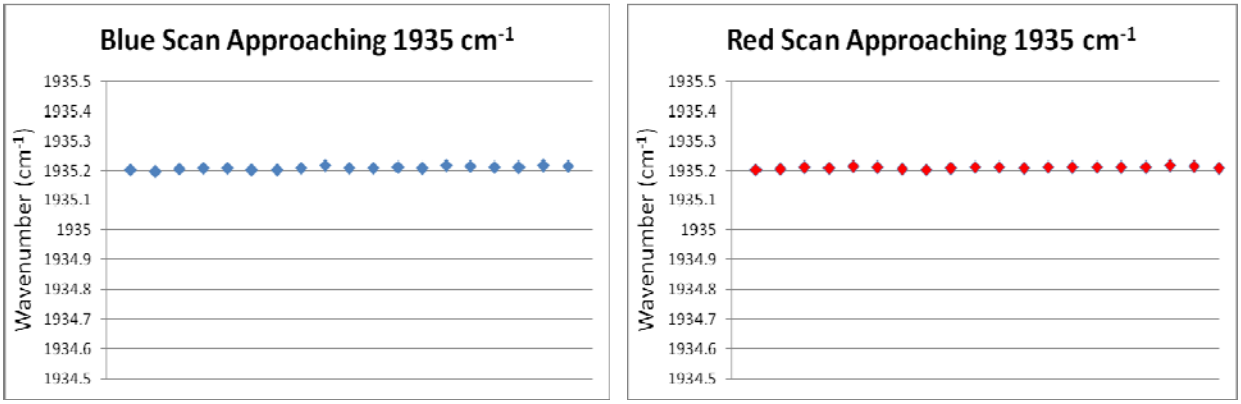
Application Note: Go-To Precision, Set-Point Accuracy and Power Cycle Accuracy of Daylight Solutions Mode Hop Free laser wavenumber set commands.

Overview:
A Daylight Solutions mode hop-free laser reaches a set range of wavenumbers without mode hopping, thus creating continuous coverage over the specified tuning range. When the laser is sent to a wavenumber within this range, via the laser controller or a terminal emulator, the grating is adjusted based on an internal calibration. Manufacturing specifications require that laser wavenumber accuracy is ≤ 0.5 cm^{-1} of requested wavenumber. This specification, called "Set-Point Accuracy," is the average error of the difference between the requested wavenumber and actual wavenumber (as read by a wavemeter). Another specification, "Go-To Precision," characterizes the precision with which the laser can be set and is calculated as the standard deviation of wavenumber readings after successively requesting the laser to go to a specific wavenumber. Manufacturing specifications require this value to be ≤ 0.02 cm^{-1}.These two calculations indicate how well the laser is calibrated and the reproducibility of the calibration.

Red Scan versus Blue Scan:
When a laser is sent to a specific wavenumber, the wavenumber can either be approached from higher or lower wavenumbers. A "blue" scan approaches the desired wavenumber from higher wavenumbers (or lower wavelengths). A "red" scan approaches the desired wavenumber from lower wavenumbers (or higher wavelengths). Due to a finite amount of backlash within the tuning mechanism, the precise wavenumber to which the laser will be set could be different when approaching from higher or lower wavenumbers. A test was set up during which two distinct wavenumbers were approached from one side, then the other side twenty times. **Graph 1** and **graph 2** show the spread of these values for both scans.



Graph 1a. Distribution of wavenumbers reached when approaching 1945 cm^{-1} from larger wavenumbers.
Graph 1b. Distribution of wavenumbers reached when approaching 1945 cm^{-1} from smaller wavenumbers.



Graph 2a. Distribution of wavenumbers reached when approaching 1935 cm^{-1} from larger wavenumbers.
Graph 2b. Distribution of wavenumbers reached when approaching 1935 cm^{-1} from smaller wavenumbers.

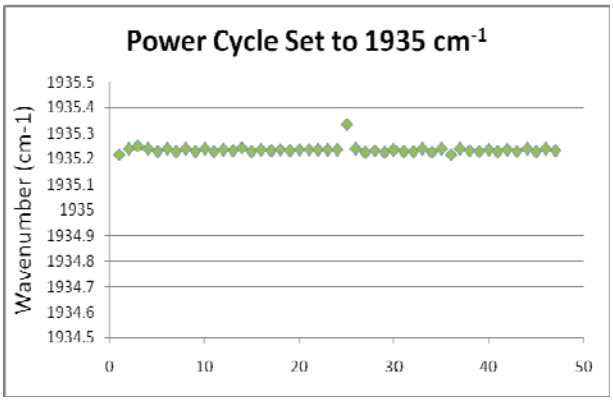
The accuracy and precision of the two different scans were determined for both wavenumbers. **Table 1** displays this data.

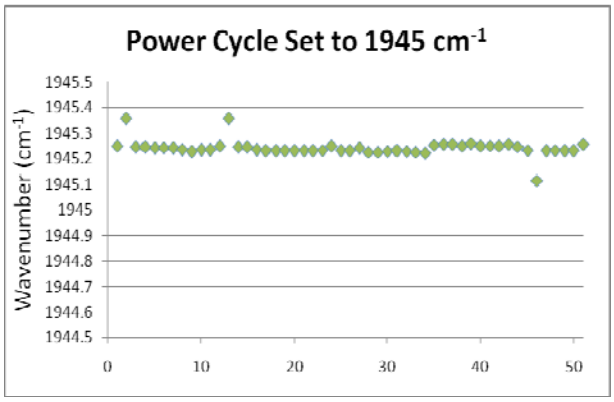
	Red Scan		Blue Scan	
	Precision	Accuracy	Precision	Accuracy
1935 cm^{-1}	0.013	0.219	0.008	0.254
1945 cm^{-1}	0.007	0.225	0.013	0.214

Table 1. Set-Point Accuracy and Go-To Precision.
λ_1 = 1935 cm^{-1}; λ_2 = 1945 cm^{-1}

This table shows that there is no difference in approaching the desired wavenumber from larger wavenumbers than from smaller wavenumbers. Both approaches provide an accuracy < 0.5 cm^{-1} and a precision < 0.02 cm^{-1}.

Power Cycling:
Another concern is the effect of power cycling on the Set-Point Accuracy. There is the possibility that when a laser is re-started, it could lase on a different mode than during the previous use cycle. This would result in lasing at an incorrect wavenumber. In order to test this concern, a power cycle test was performed. The wavenumber was determined, the laser was power cycled, and then the wavenumber was determined again. This procedure was looped fifty times. **Graph 3** shows the spread of these values.





Graph 3a. Distribution of wavenumbers reached when power cycling and sending the laser to 1935 cm^{-1}.
Graph 3b. Distribution of wavenumbers reached when power cycling and sending the laser to 1945 cm^{-1}.

Table 2 presents the Go-To Accuracy of the aforementioned test.

Power Cycle Accuracy	
λ= 1935 cm^{-1}	λ= 1435 cm^{-1}
0.239	0.25

Table 2. Wave number Accuracy of power cycling.

During power-cycling the accuracy was approximately 0.25 cm^{-1}. The mode spacing of the cavity is on the order of 0.2 cm^{-1} to 0.5 cm^{-1}. It is possible that the laser is stabilizing on an adjacent mode during power up, but it remains within the 0.5 cm^{-1} accuracy specification.