Laser Locking and Optimization Technical Bulletin

Introduction:

The incorporation (or retrofit) of the Tiger Optics *Reference Cell* provides a more convenient and continuous means to verify that the laser remains at exactly the requisite wavelength.

Background:

Tiger Optics' analyzers do not require traditional field calibration. Our laser-locked CW-CRDS analyzers are self-calibrating. Because they are based on fundamental physical principles, they require no external calibration gases; they need no built-in zero calibration purifiers; and they do not require permeation tubes. Tiger Optics analyzers are therefore very reliable and simple to operate. In addition, our analyzers do not have the maintenance requirements, down-time, or costs associated with the calibration techniques required by our competitors' devices.

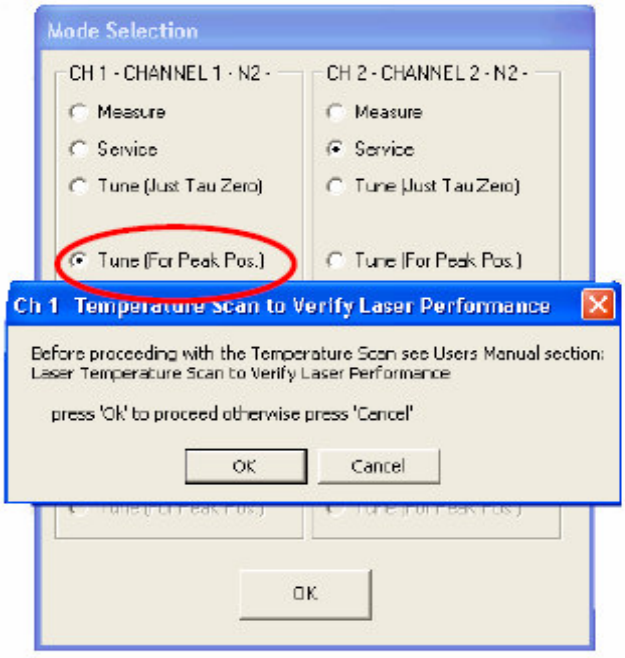
Tiger Optics' CW-CRDS analyzers measure the time (in microseconds) for light to decay ("ring down") inside an optical cavity. When the laser is cut off, the light travels back and forth between two mirrors up to 100,000 times in less than one second. The optical losses in the cavity reduce the amount of light with each pass, allowing us to measure a "ring-down time." When *N*-number of target molecules are present in the gas flowing through the cavity, they absorb light, therefore shortening the ring-down time, as predicted from the ***Beer-Lambert law***: $N \propto \left(\frac{1}{\tau(\nu)} - \frac{1}{\tau_{zero}} \right)$.

"**Tau**", $\tau(\nu)$, is the ring-down time measured in the cavity when there is an absorbing species in the sample gas (e.g., H_2O in N_2), and the laser is emitting light at a wavelength, ν, where those molecules will absorb light. To ensure that the laser remains at the correct wavelength, Tiger Optics offers ***two proven methods***.

Two Means to Ensure Laser On-Peak Position:

1. Tune for Peak Position

The software function "Tune (for Peak Position)" provides an automated measurement verification capability. This function *checks* and, if necessary, *adjusts* the laser temperature, so the wavelength of light emitted from the laser is centered on the wavelength for the absorption peak. Thus, it compensates for any potential drift in the wavelength of light emitted by the laser. We recommend this check be performed every ***6 months*** for units ***without reference cells*** (see next section).

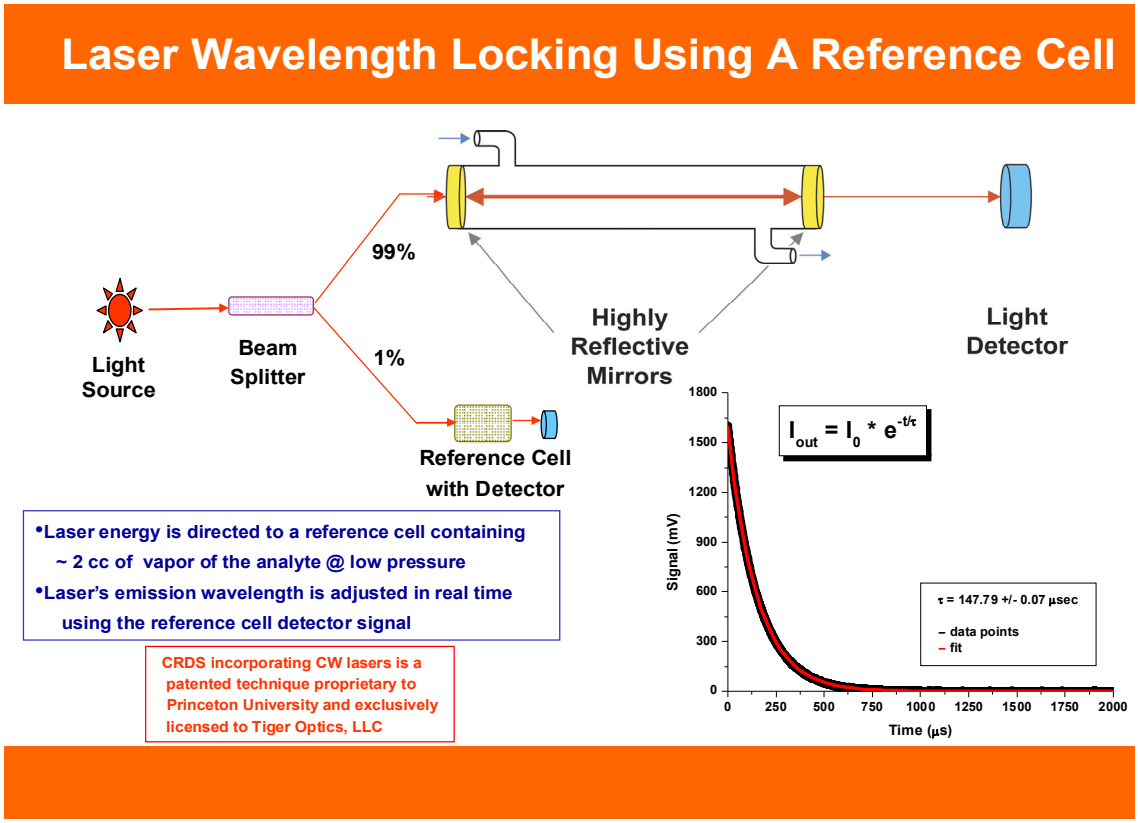


2. Reference Cell

All HALO's, all LP-type analyzers, and all analyzers manufactured after March 2007 contain a *Reference Cell* that automatically re-centers the laser during measurements. The Reference Cell itself is a small, permanently sealed container of the target analyte.

Using a beam splitter to direct ~1% of the laser light to the Reference Cell, the analyzer makes minute adjustments, if needed, to the laser current. This continuously verifies that the laser remains on the correct wavelength. (See illustration below.)

Given this capability, we recommend a "Scan" or "Tune for Peak Position", also known as "Optimize Laser", only every ***12 months*** for units ***with reference cells***. This quick one-touch procedure automatically resets the laser current and temperature as required to maintain optimum performance.



Conclusion:

The Tiger Optics R&D Team has selected our two on-line Laser Optimization methods for system verification based on their *precision, reliability* and *simplicity*. These give a significant advantage to our users, especially when compared to our competitors' analyzers that use other zero calibration methods. The "self-verification" of our laser-locked CW-CRDS analyzers is one of the reasons why more than 16 national metrology labs have adopted our absolute technology as a transfer standard.