Simple squematic illustration of the Cavity Ring-Down procedures for measurement of the absorption in gases

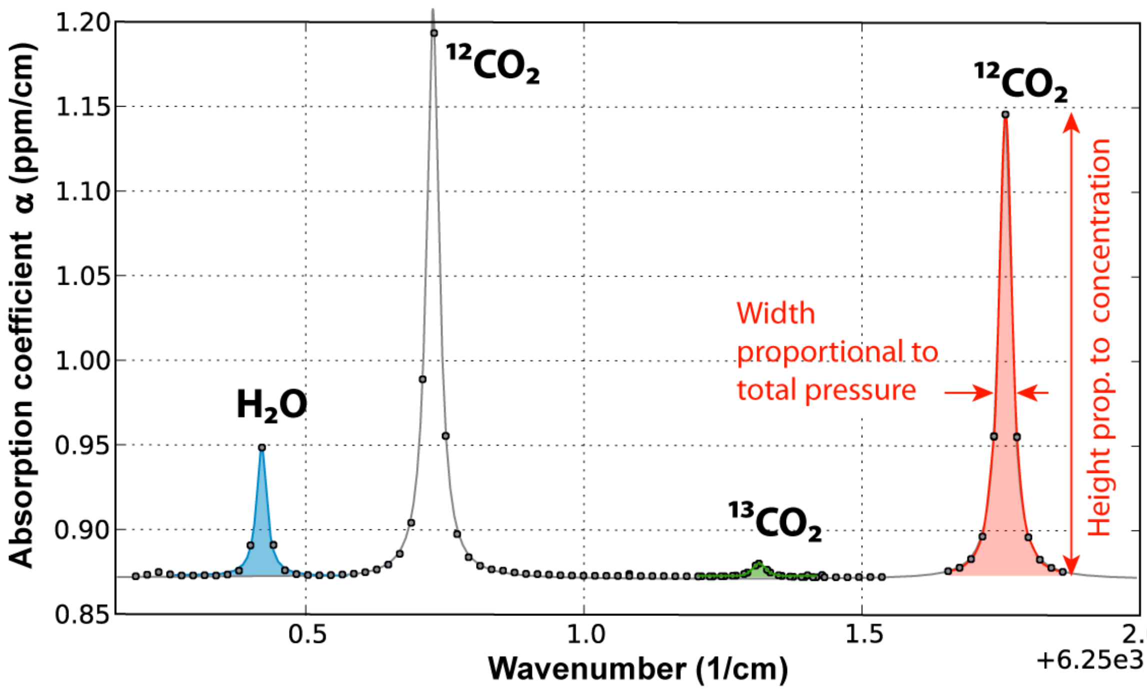

Figure 1: Spectrum applied by the CRLAS analyzer. Highlighted with green area is the $^{13}CO2$ absorption line and in Red $^{12}CO2$. The magnitude of these areas quantifies their concentrations. Rather than wavelength the spectrum is plotted using wavenumbers which are typically more convenient numbers.

A tunable diode laser is targeted onto the optical cavity. This optical cavity consists of three optical mirrors which are aligned such that the laser beam forms a closed path on every round trip. The cavity is essentially opaque due to the high reflectivity of the mirrors (ca.99.99%). But for wavelengths being an integer fraction of the cavity round trip, high transmission of power is possible because the oscillations of the incoming light matches phase with that circulating in the cavity, injected earlier by the same beam. In wavelength space this provide a grid $\lambda_m = L/m$ where L is the cavity round trip, m is an integer and λ_m is the wavelengths for which the laser will be on transmission resonance. The round gray data points in Figure1 fall exactly on such a transmission grid. The difference in light frequency between these transmission resonances is called the free spectral range denoted FSR = L/c. By changing the cavity length the transmission grid can be shifted such that any optical wavelength can be transmitted, see Figure 2.

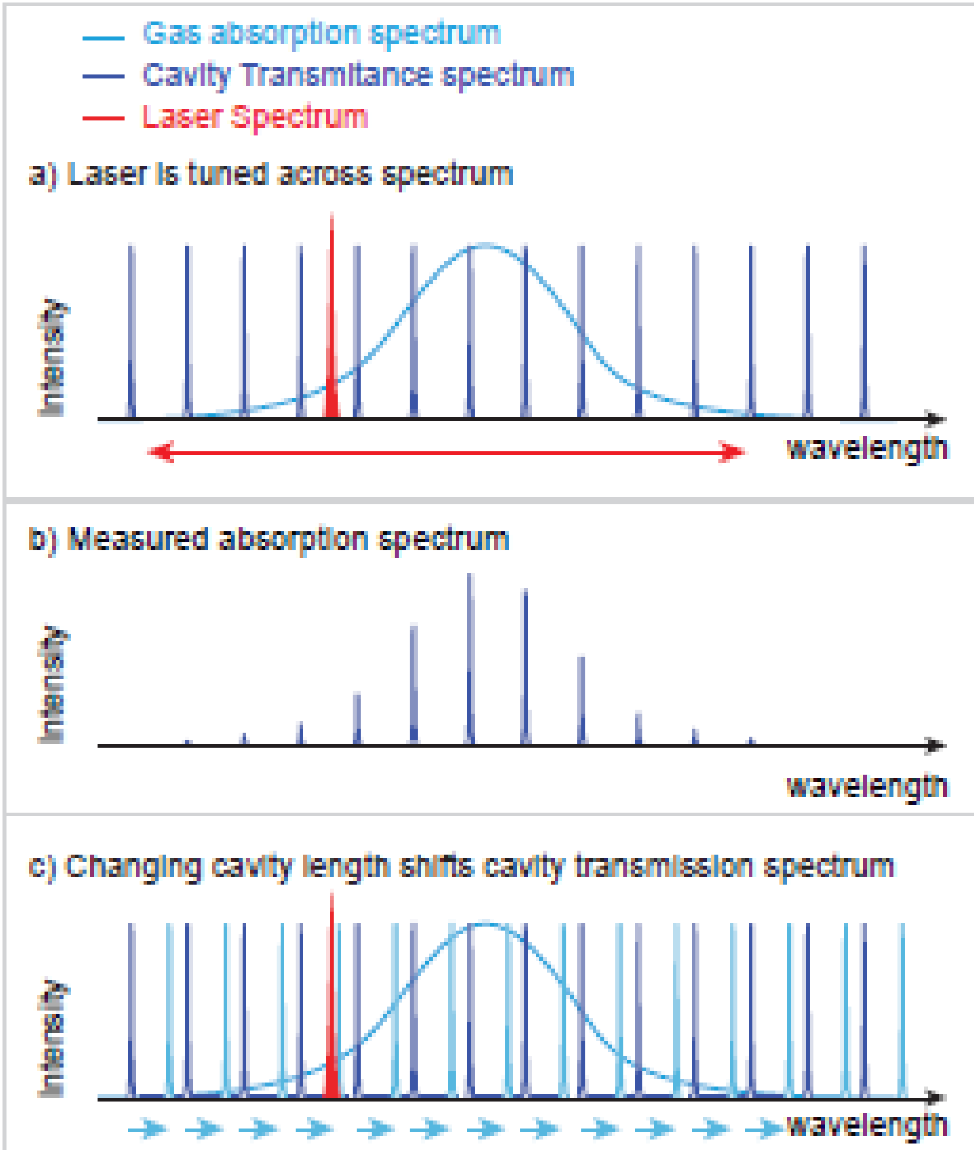

Figure 2: Spectra of cavity transmis-sion and gas absorption. The gas absorption is sampled at the cavity trans-mission wavelengths. The latter can be shifted by changing the cavity length.

By changing the cavity length the transmission grid can be shifted such that any optical wavelength can be transmitted, see Figure 2. The cavity length is changed by using a piezo electric actuator to move the position of a cavity mirror, see Figure 3. This is an important attribute for targeting measurements at the peak of an absorption line. The continuous wave (cw) lasers commonly applied have an intensity spectrum which is much narrower than the spacing between the transmission modes of the cavity. So the laser is not automatically resonance with the cavity.

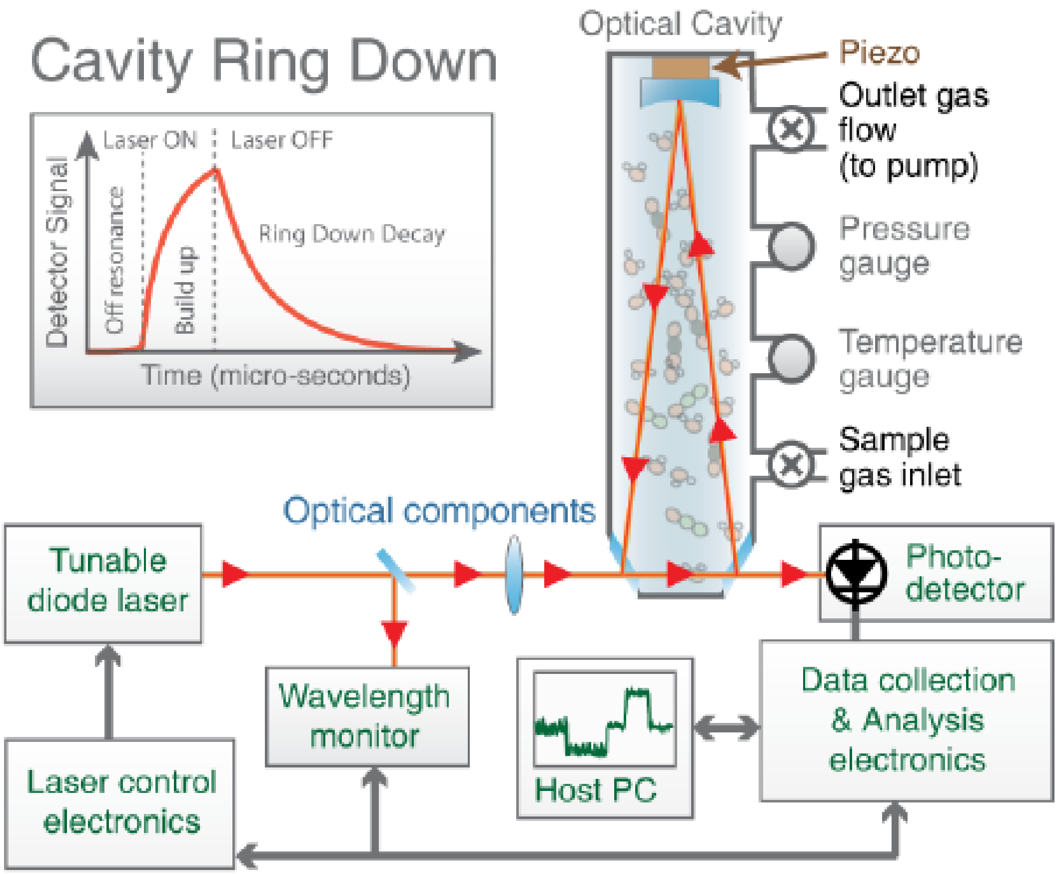

Figure 3: Diagram of the essential components in the CRDS analyzer.

To quantify the optical absorption, the CRLAS analyzer performs a cavity ring down measurement, see plot in Figure 3. A photo detector monitors the amount of light in the cavity. When laser and cavity are not on resonance no signal is detected. Once the laser hits resonance with one of the cavity modes, a transmission signal will build up stochastically. This is monitored by the electronics, and when the intensity reaches a preset threshold the electronics will turn o_ the laser, which happens in less than 100 ns. In the cavity, light is trapped between the mirrors and exhibits an exponentially decay in intensity (known as the cavity ring down) which may last for as long as 40 µs or even more. The intra cavity laser power may be more than 10000 times higher than that exposed to the photo-detector. The entrapped light field loses power through the mirrors and due to prospective analyte absorbers. The more absorption is present in the cavity the faster the decay will be.