ATTREX / Picarro Installation

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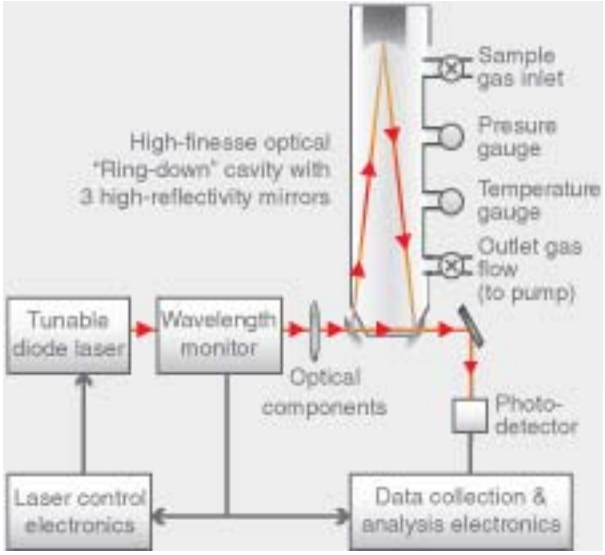
Picarro / Instrument Description

- Measure technique is Cavity Ring-Down Spectroscopy (CRDS)
- 3 lasers are used, with each with a wavelength between 1.55 and 1.65 µm
- Wavelength monitor maintains very precise laser output
- Cell pressure is maintained at 140 ± 0.03 torr, temperature at 45 ± 0.02 C
- Cavity length is 25 cm, path length exceeds 20 km
- Cavity volume approx. 33 cc
- 3 high refl. mirrors are used within the cavity
- Fiber optic optical coupling



Picarro / Instrument Performance

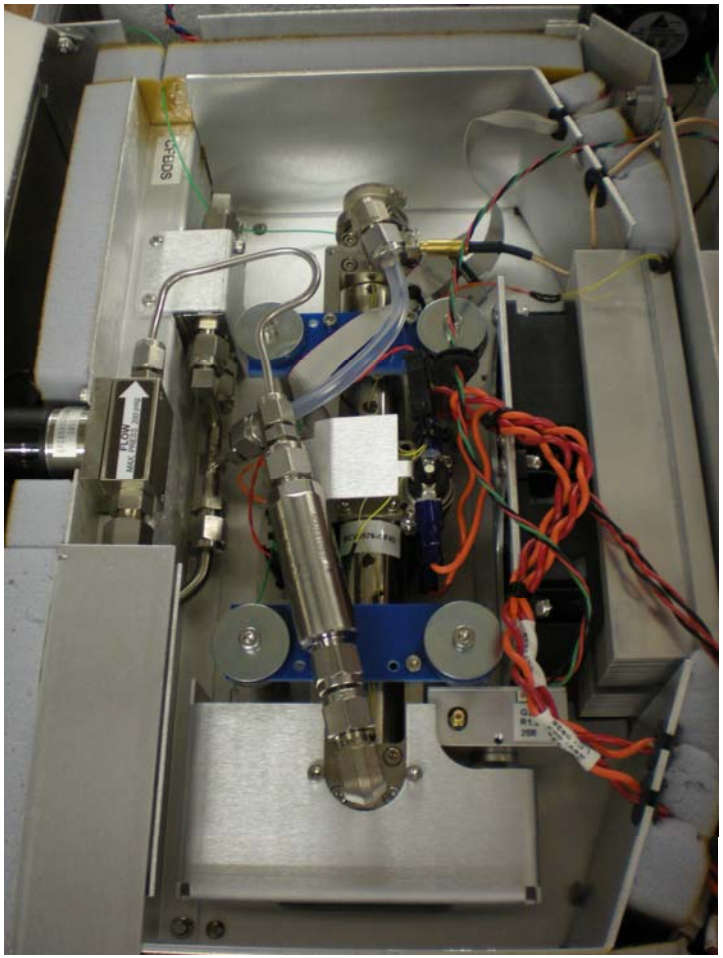
- Current Precision Specifications (5 s. average):

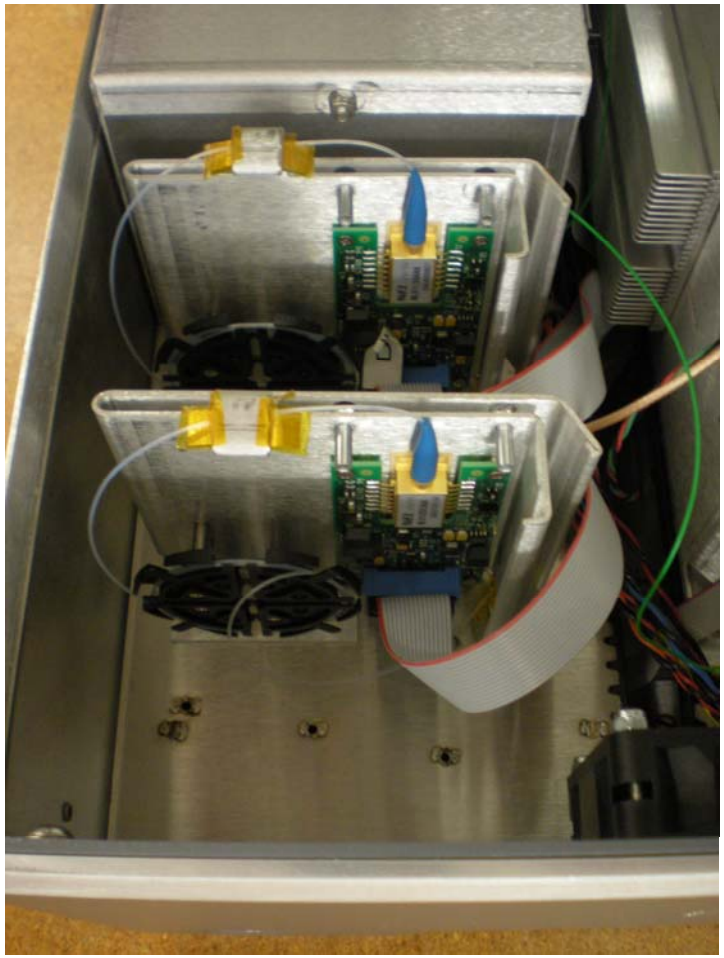
CO	< 40 ppb
CH_4	< 1.5 ppb
CO_2	< 200 ppb

- Nominal Operating Parameters (as received):

Ambient temperature:	10 to 35 C, RH 0 to 99%, non-cond.
Ambient pressure:	> 250 torr
Sample inlet pressure:	250 to 1000 torr
Sample flowrate:	1000 sccm
Data output rate:	1 Hz
Dimensions:	17W x 17.5D x 7”H (43 x 44 x 18 cm)
Weight (basic unit only):	58 lbs. (26.3 kg)
Power consumption:	< 370 W (115VAC 60 Hz)

Picarro / Cell and Lasers





Picarro / Required Modifications

- Picarro is working to improve CO precision. Results unknown at this time, information should be available within 2 months. If inadequate, Plan B is to use UCATS for CO.

- If the instrument is located in an unpressurized location, a pressure vessel will be required. This will likely necessitate repackaging of the detector components to minimize the PV volume. Despite this requirement, it is the preferred option.

- The provided internal Power Supply will be replaced with a wide 28VDC input unit.

- Brushless DC diaphragm pumps will be added upstream and downstream of the instrument to provide sample flow over the required pressure range. The provided pressure controllers will be modified as required to achieve desired performance.

- Water vapor will be removed from the sample air.

- Two external calibration standards (mixtures of CO, CH_4, and CO_2) will be added to provide in-flight verification of the instrument performance. Bottles are 8.4L, carbon fiber wrapped aluminum.

- The instrument will be temperature controlled in flight (heated). Operation on the ground at Dryden in summer conditions will be a challenge.

Info from Picarro Website

- When the photodetector signal reaches a threshold level (in a few tens of microseconds), the continuous wave (CW) laser is abruptly turned off. The light already within the cavity continues to bounce between the mirrors (about 100,000 times), but because the mirrors have slightly less than 100% reflectivity (99.999%), the light intensity inside the cavity steadily leaks out and decays to zero in an exponential fashion. This decay, or "ring down", is measured in real-time by the photodetector and the amount of time it takes for the ring down to happen is determined solely by the reflectivity of the mirrors (for an empty cavity). Consider that for a Picarro cavity of only 25 cm in length, the effective pathlength within the cavity can be over 20 kilometers.

- Now, if a gas species that absorbs the laser light is introduced into the cavity, a second loss mechanism within the cavity (absorption) is now introduced. This accelerates the ring down time compared to a cavity without any additional absorption due to a targeted gas species. Picarro instruments automatically and continuously calculate and compare the ring down time of the cavity with and without absorption due to the target gas species. This produces precise, quantitative measurements that account for any intra-cavity loss that may be changing over time, and it allows the discrimination of loss due to absorption from losses due to the cavity mirrors. Furthermore, the final concentration data is particularly robust because it is derived from the difference between these ring down times and is therefore independent of laser intensity fluctuations or absolute laser power.

- This scheme of comparing the ring down time of the cavity without any absorbing gas, with the ring down time when a target gas is absorbing light is accomplished - not by removing the gas from the cavity - but rather, by using a laser whose wavelength can be tuned. By tuning the laser to different wavelengths - where the gas absorbs light, and then to wavelengths where the gas does not absorb light - the "cavity only" ring down time can be compared to the ring down time when a target gas is contributing to the optical loss within the cavity. In fact, the laser is tuned to several locations across the target gas's spectral absorption line (and ring down measurements are conducted at all these points) and a mathematical fit to the shape of that absorption line is what is actually used to calculate the gas concentration.

Info from Picarro Website

- **i) Absolute wavelength monitoring**
- Pushing CRDS to the parts per trillion (ppt) level requires very precise scanning and fitting of the target absorption line. The wavelength of the available near-IR laser diodes is directly tuned by changing its drive current and temperature. However, the exact relationship between current and wavelength varies from laser to laser. Moreover, because this relationship can change over time, the wavelength cannot be known from the drive current alone. Additionally, it is necessary to know the absolute value of the laser wavelength to a precision that is a few orders of magnitude narrower than the spectral linewidth. Commercial wavemeters, however, don't offer this precision. This is the main reason that older, competitive cavity-based instruments try to lock to a single wavelength rather than scan across the entire absorption line.

- At Picarro we solved this problem by developing and patenting our own wavelength monitor. It can measure absolute laser wavelength to a precision more than 1000 times narrower than the observed Doppler-broadened linewidth for small gas phase molecules. We then use this in a novel way - specifically, we lock the laser to the wavemeter which we then actively tune to known wavelengths. The result is higher spectral precision than in any commercial spectrometer - laser-based or otherwise. This spectral precision is the key to the ultra-precise fitting of lineshapes and line heights necessary to reach parts per trillion concentration sensitivity.