

PICARRO

**Cavity Ring-Down Spectroscopy (CRDS):
High precision measurements suitable for
field, mobile and lab-based work**

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Rob Peters, Sales Specialist**

University of Bristol, May 7th, 2013

Outline

- Introduction Picarro and CRDS technology **R. Peters**
- Greenhouse Gas analyzers and applications **R. Winkler**
- Stable isotope analyzers and applications **R. Winkler**
- Mobile solutions using Picarro Investigator **R. Peters**
- UK DECC network of tall tower measurements **A. Grant**
- Final Question and Answer Period **All**



Company Intro – World Class Ops



Picarro – Who are We?

- Core Technology licensed from Stanford University
- In existence since 1997 – began with telecommunications
- Started development of products for optical spectroscopy in 2003
- Today specialize in Cavity Ring-Down Spectroscopy (CRDS)
- Based in Santa Clara, California, with offices in Europe and China
- 95 employees, 30 Ph.Ds, 26 Patents (and counting)
- Over 1500 analyzers in 57 countries

Picarro – Who are We?

Technologists



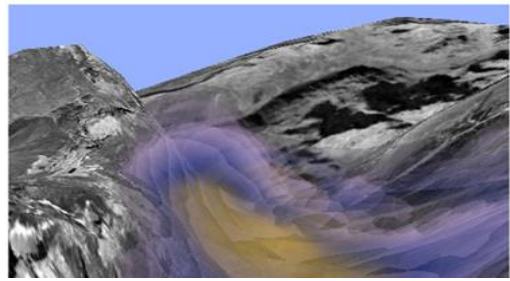
Transformers



How Green Is Davos?



A big slogan around town this year is "Toward A Greener Davos," the name of a WEF initiative aimed at "lowering the amount of pollutants" produced by the forum's 2,600 participants and their entourages. This



Participators



PG&E, Picarro Hit the Road With Gas-Sniffing Chevy Volts



Can mobile gas-sniffing units prevent another pipeline disaster?

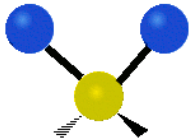
JEFF ST. JOHN: JANUARY 30, 2012

Out of all the critical infrastructure that utilities protect, none of it is more critical than natural gas pipelines that can explode and kill people. Pacific Gas & Electric is still reeling from the 2010 pipeline explosion that killed eight people in San Bruno, Calif., one that has led to a massive investigation by state officials and a promise from PG&E to invest billions of dollars in pipeline safety.

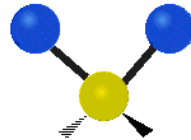
Technology

Optical spectroscopy – molecules in motion

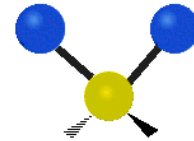
- All molecular bonds are in motion
- Frequency of the motion is dependent on the atoms and bond type
- Specific frequencies of motion relate to specific frequencies of absorption



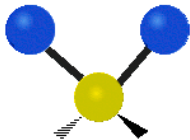
Symmetrical stretching



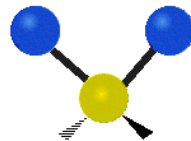
Antisymmetrical stretching



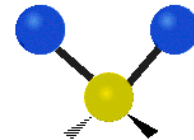
Scissoring



Rocking

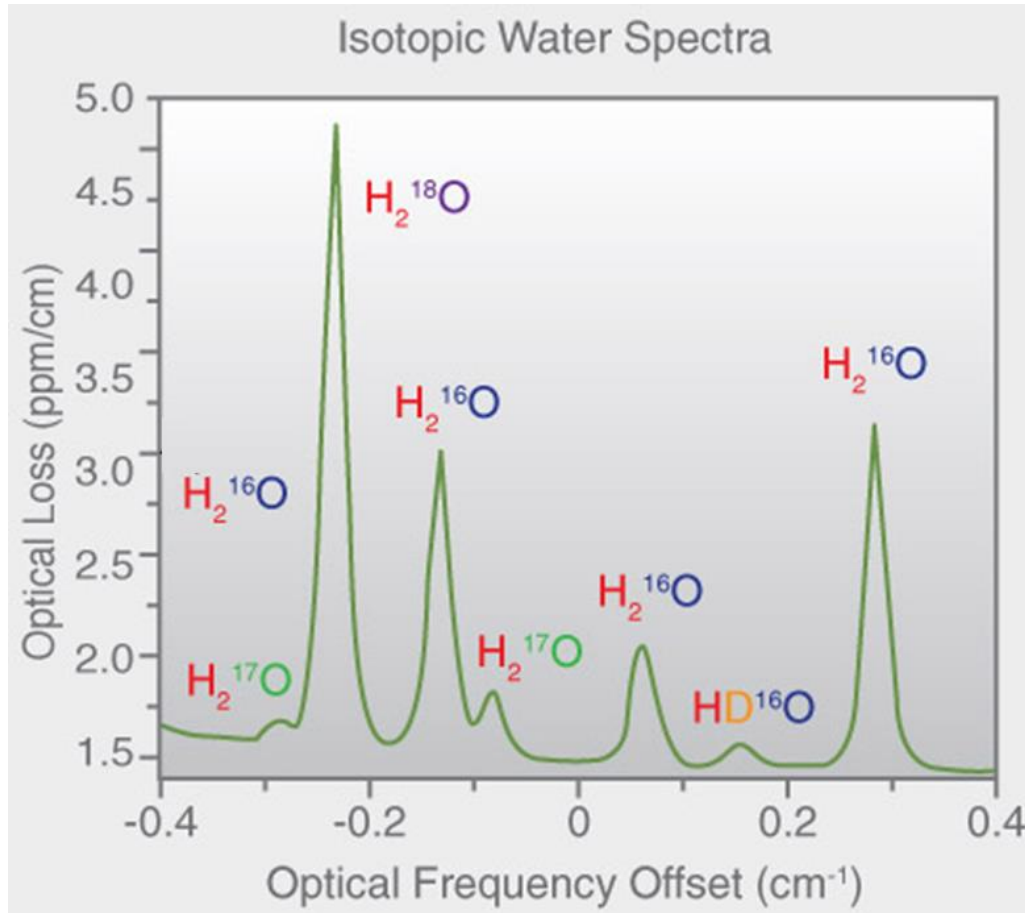


Wagging



Twisting

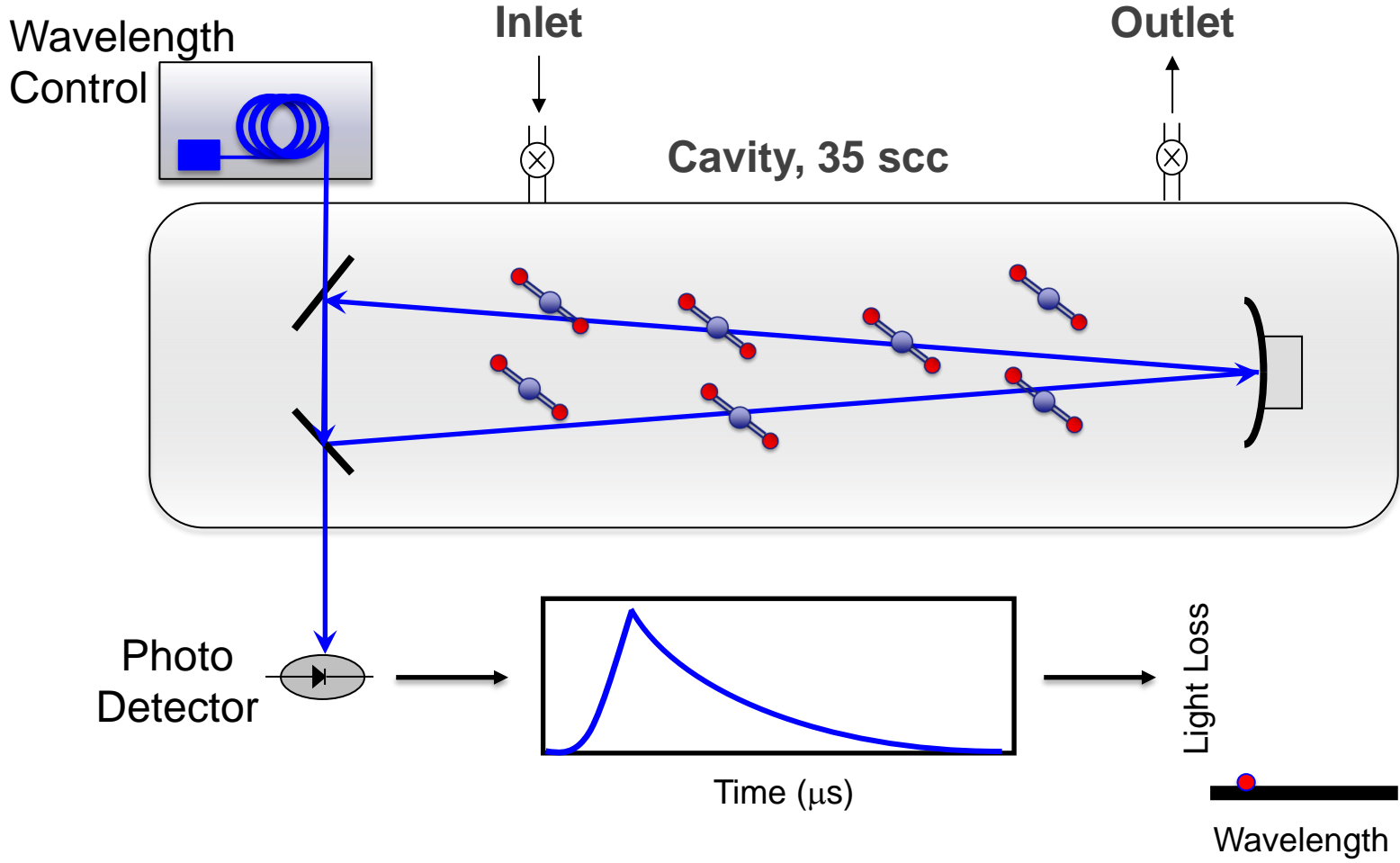
Optical spectroscopy – absorption spectra



- Beer-Lambert Law
$$A = \epsilon lc$$
- ϵ : Bond stretching frequency results in characteristic optical absorption
- l : a longer pathlength increases sensitivity ($l = 20$ km in Picarro)
- c : Signal intensity is related to quantity

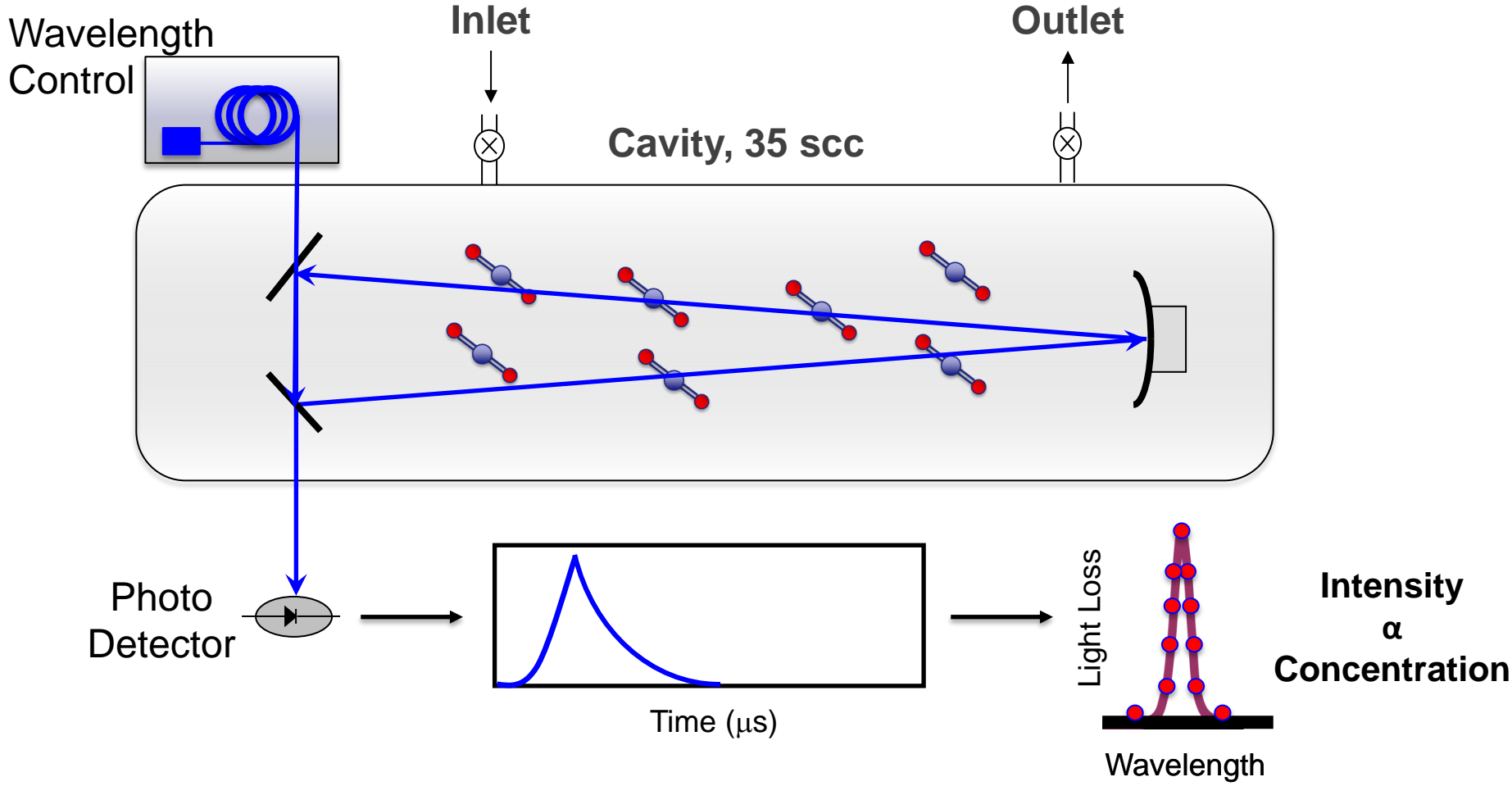
Cavity Ring-Down Spectroscopy – Hardware

- 1 – Fire a laser at a wavelength that the molecule does not absorb



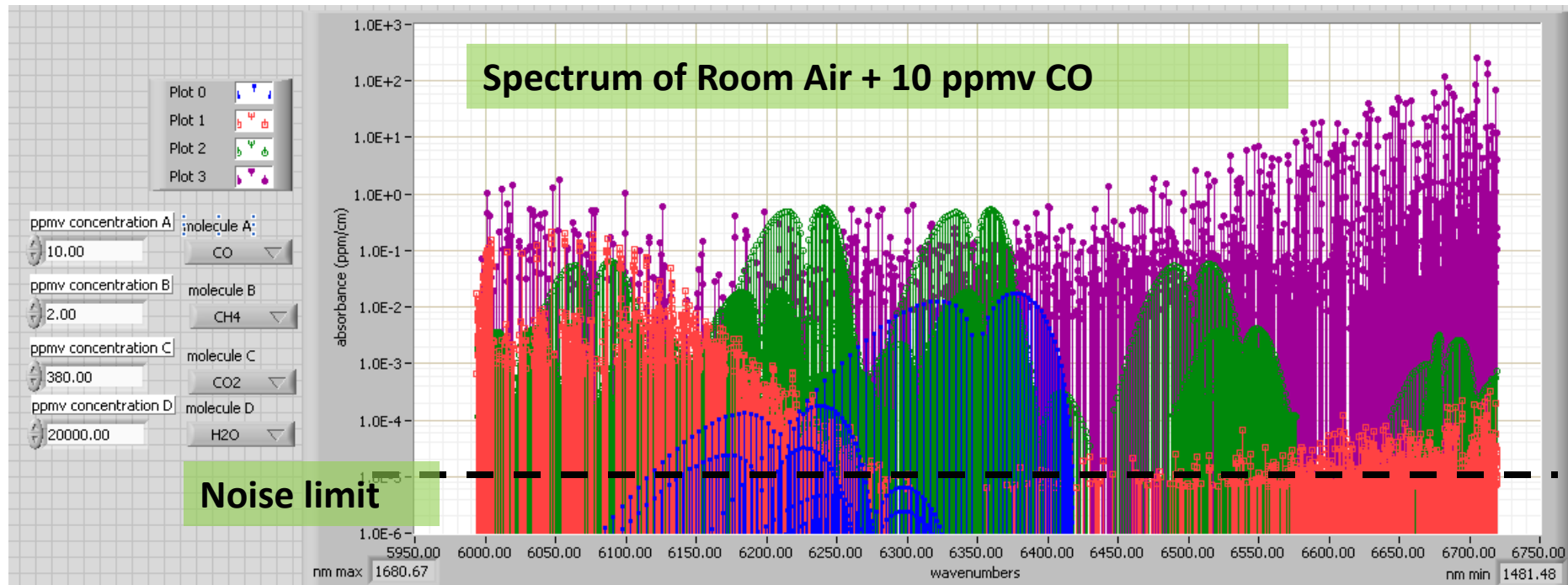
Cavity Ring-Down Spectroscopy – Hardware

- 2 – Fire a laser at a wavelength that the molecule DOES absorb



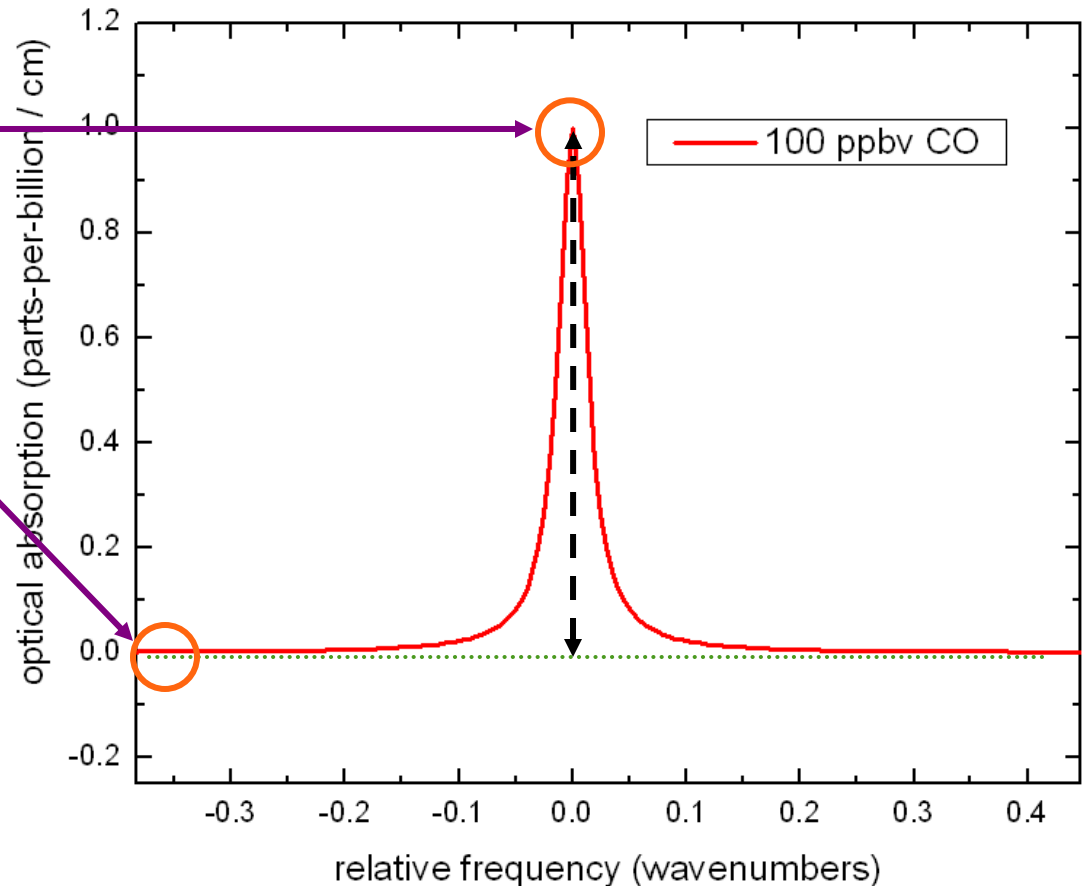
CRDS: measuring multiple species (the real world)

- Ultra-high sensitivity means that *thousands* of lines for any given species are available for analysis
- Use multiple lasers and wide-bandwidth optics to allow multi-species operation in a single device

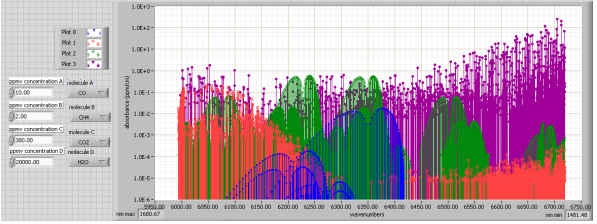
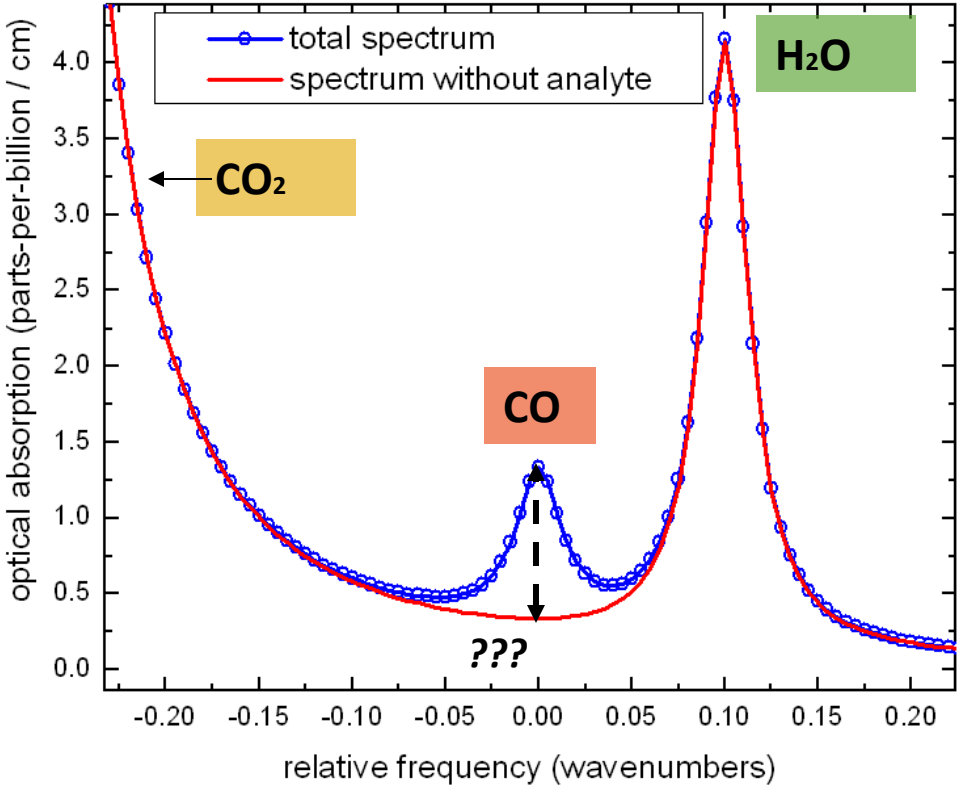


Avoiding cross-talk: “ideal world”

- Measure the peak height here (on-resonance)
- Measure the baseline here (off-resonance)
- The concentration is proportional to the difference between peak and baseline



Real world spectroscopy: lines are everywhere

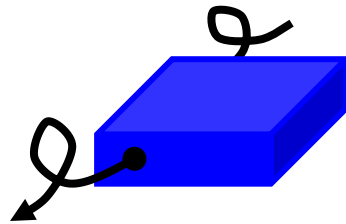


In the real world, you can measure only the blue circles, not the red line

- Measuring the peak is easy, but...
- *How do you measure the baseline under the peak?*

Picarro wavelength monitor: spectroscopic GPS

- Proprietary optical sensing technology
- Broadband, fiber-coupled device
- Stabilized to environmental fluctuations
- Single shot precision of **8 femtometers** in the near infrared



Picarro wavelength precision

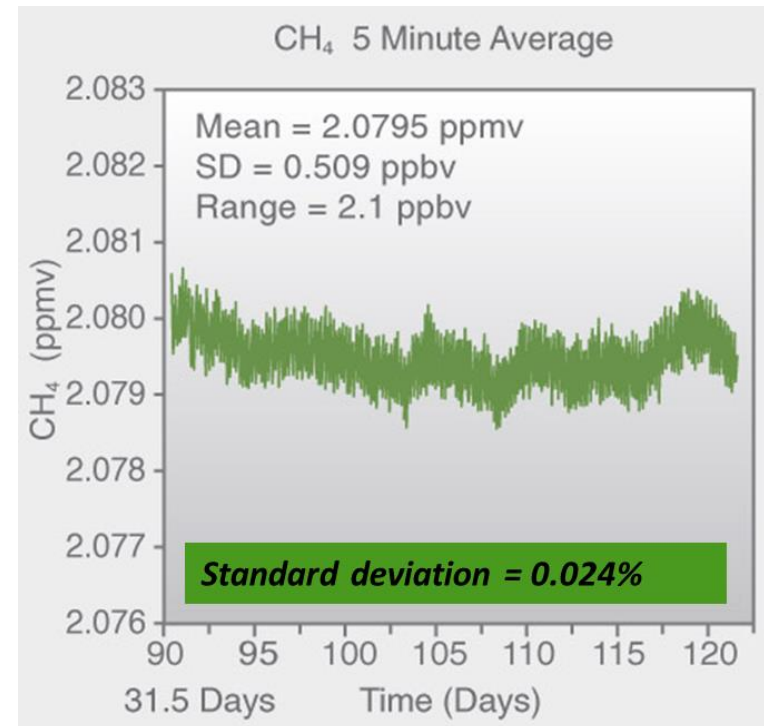
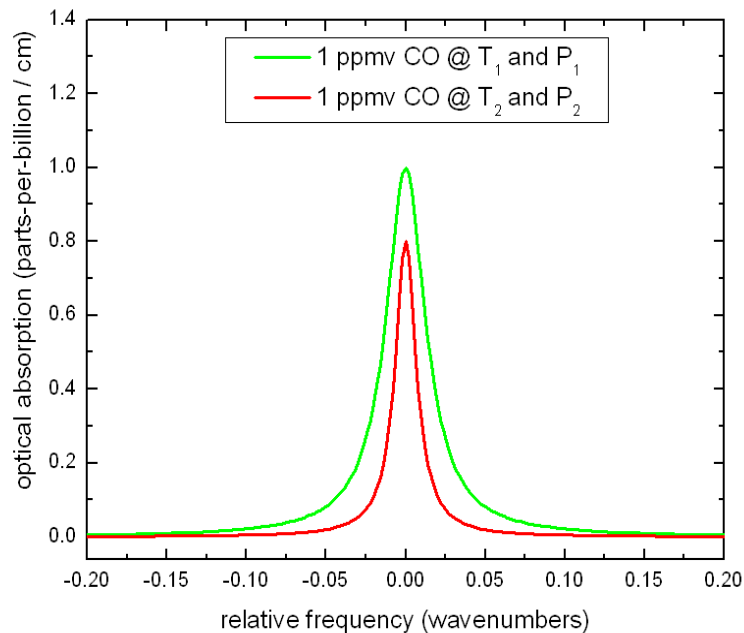


Cavity Ring-Down Spectroscopy – Hardware

ALL spectroscopic techniques are affected by temperature and pressure variations.

Must control the variables that affect the spectroscopic signals:

- Temperature to ± 0.005 °C
- Pressure to ± 0.0001 Atm



Cavity Ring-Down Spectroscopy – Hardware

“drop tested according to MIL-STD 810F standard test (4" height, 12 edges (x,y,z axes), 2 drops each edge) and vibration tested (2 axis, 25 Hz, 1gp-p acceleration, 15 minutes each axis) during manufacturing to prove ruggedness in the field”

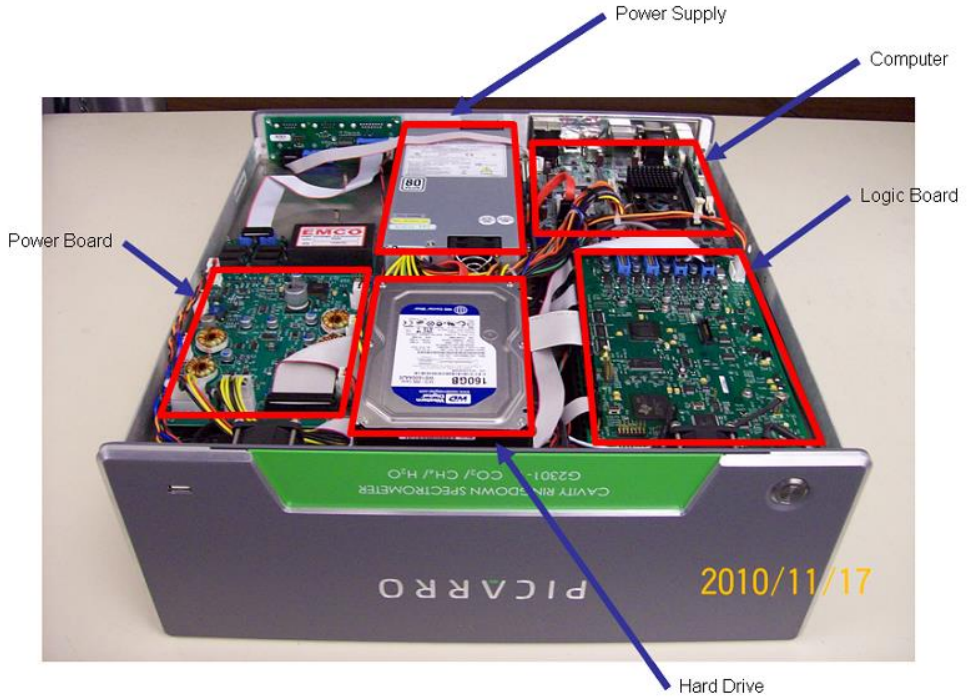
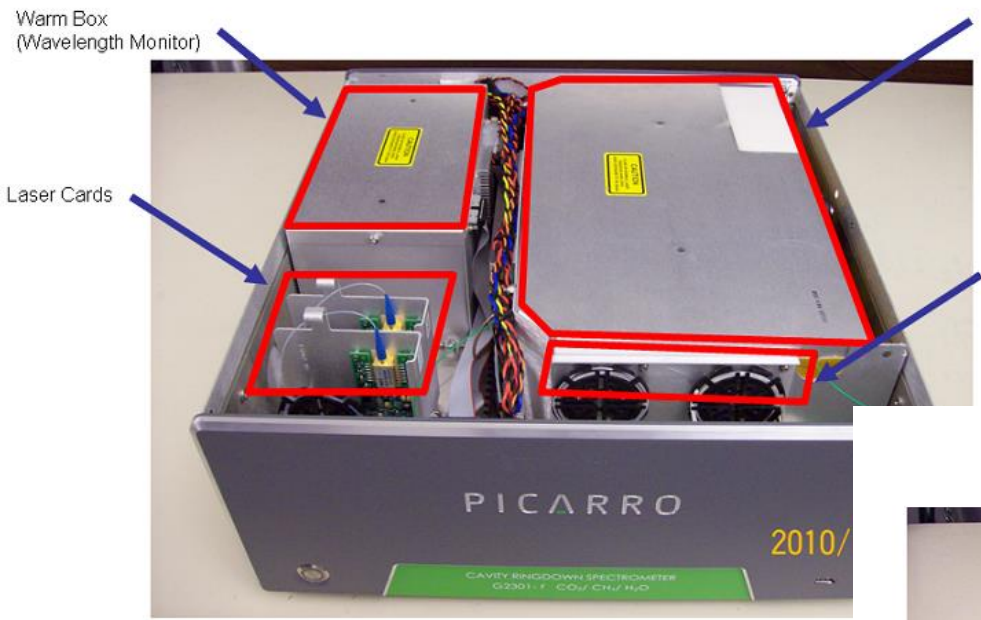


Clean and Simple Design



- PC is built-in, pre-installed with Windows and all necessary software, including data integration
- Compact and Plug-and-Play
- Portable – Networkable – Interfaceable

Inside the box



Cutting-edge technology that is easy to use

Start-up Procedure



- Connect vacuum and inlet tubing
- Connect AC power, keyboard, mouse, monitor
- Turn on Pump
- Press start button
- Get cup of coffee while instrument warms up
- Enjoy your data!

Suitable for Virtually any Situation



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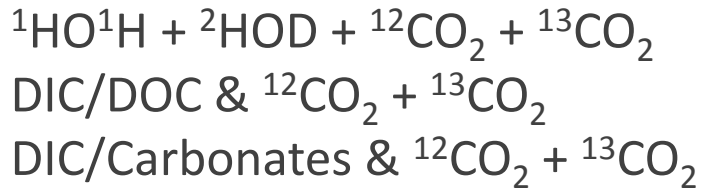
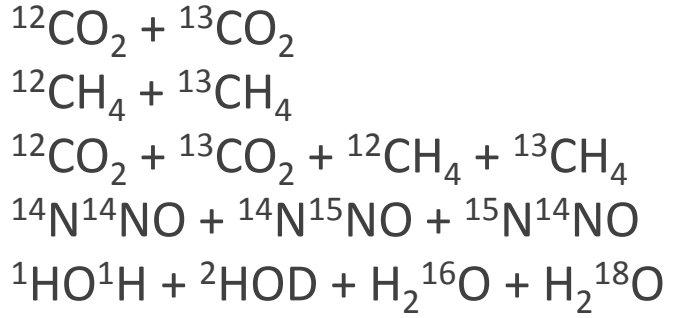
Cavity Ring-Down Spectroscopy - Analytes

Concentration only

- G2103: NH₃
- G2114: H₂O₂
- G2205: HF + H₂O
- G5105: N₂O
- G2203: CH₄ + C₂H₂
- G2204: CH₄ + H₂S
- G2301: CO₂ + CH₄ + H₂O
- G2401: CO₂ + CH₄ + CO + H₂O
- G2508: N₂O + CO₂ + CH₄ + NH₃ + H₂O

Stable Isotopes

- G2131: δ¹³C in CO₂
- G2132: δ¹³C in CH₄
- G2201-i: δ¹³C in CO₂ and CH₄
- G5101-i: δ¹⁵N in N₂O
- L2130-i: δD and δ¹⁸O in H₂O
- B2221-i: δD & δ¹³C in H₂O & CO₂
- Aurora-CRDS: DIC/DOC & δ¹³C in CO₂
- Automate-CRDS: DIC/carbonates + iCO₂

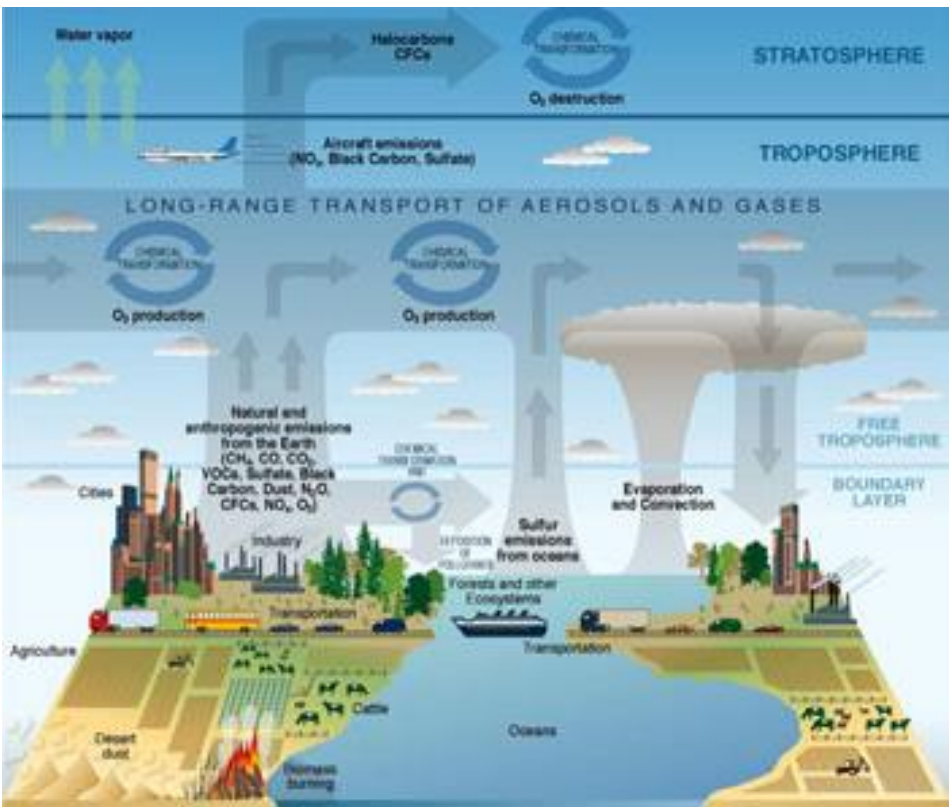


Markets

Atmospheric Science - GHG



Flux GHG Analyzer
Rapid gas exchange
Metabolic Process



Isotopic H₂O
Source/Fate Water
Vapour



Isotopic N₂O
Source/Fate Nitrogen
Metabolic Process

Ecology



Isotopic H₂O
Source/Fate Water



Isotopic CO₂ + CH₄
Source/Fate Carbon
Metabolic Process



Flux GHG Analyzer
Rapid gas exchange
Metabolic Process



Isotopic N₂O
Source/Fate Nitrogen
Metabolic Process



¹³C + D
Food Web,
Migration

Hydrology

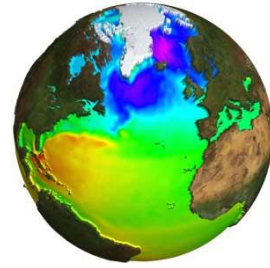
Agriculture
Water Use Efficiency



Glaciology
Climate Change



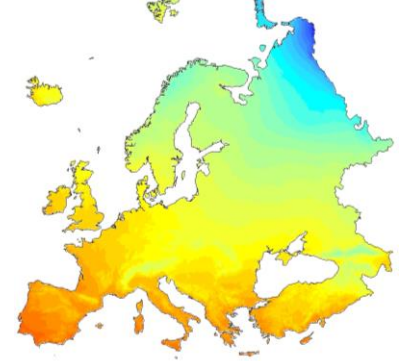
Oceanography
Circulation



Atmosphere/Metrology
Water Vapor



Freshwater
Water Source Mapping



Biology



Animal Metabolism
Measure Respired $^{13}\text{CO}_2$



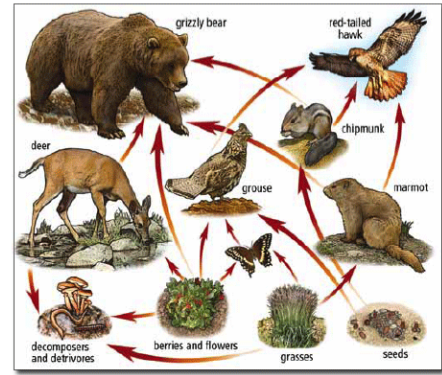
Human Metabolism
Double Labelled Water



Animal Migration
Measure Feather $^{13}\text{C} + \text{D}$



Archaeology
 $^{13}\text{C} + \text{D}$ to tell diet

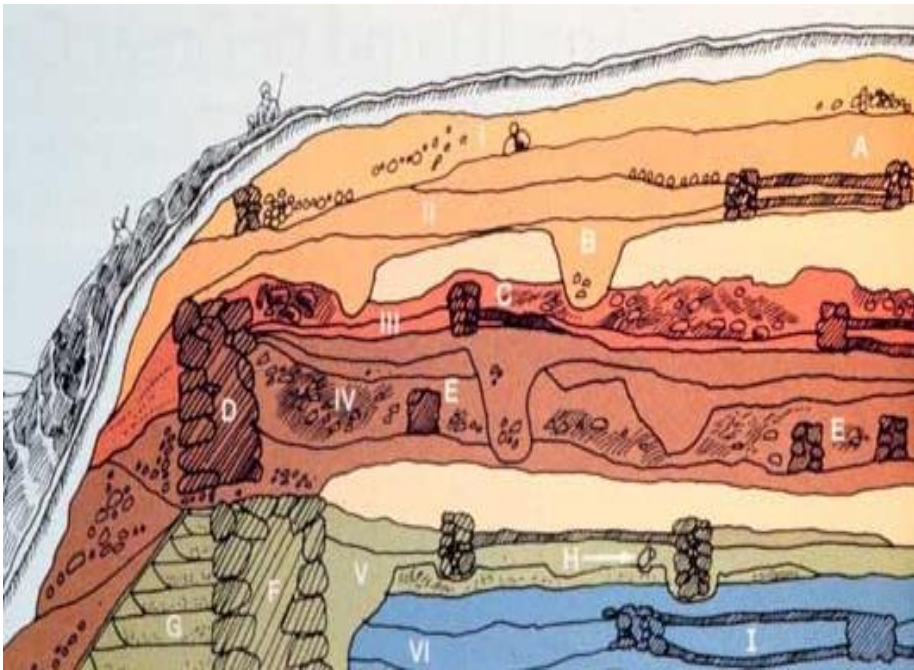


Food Web
Measure $^{13}\text{C} + \text{D}$

Geology



Geological Gas Analysis
 $^{13}\text{CO}_2$ and $^{13}\text{CH}_4$



Paleo Biosignatures
 $^{13}\text{C} + \text{D}$



Source Rock Analysis
 $^{13}\text{C} + \text{D}$



Geothermal Fluids
Isotopic H_2O
Isotopic Carbonates

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Picarro community

A forum for users to ask questions and share experience, knowledge and know-how

The screenshot shows the Picarro community website in a browser window. The browser's address bar displays www.picarro.com/community/picarro_community. The website header includes the Picarro logo, the tagline "The World's Leading Instruments for Carbon and Water Cycle Measurements", and user information for Robert Panetta. A navigation menu lists "Markets Served", "Gas Analyzers", "Isotope Analyzers", "Services", "Help/Resources", "Technology", and "Community".

The main content area is titled "Community" and features a search bar and "New Topic" and "Mark All Read" buttons. Below this is a table of forum topics:

TOPIC	REPLIES	VIEWS	CREATED	LAST REPLY
Pulse Analysis failure updated	3 3 new	14	by SamanthaWheeler Oct 5 2012 - 8:24am	by Aaron Van Pelt 51 min 6 sec ago
What does Instrument Status ("INST_STATUS") column in G2000 data log mean? (most of the time its value = 963) new	0	0	by Alex Lee 3 hours 49 min ago	n/a
Re-flashing the CTC Autosampler Firmware updated	1 1 new	31	by Aaron Van Pelt Jun 22 2011 - 9:14pm	by Alex Lee 11 hours 7 min ago
CRDS Coordinator does not Update Sample Information (L2120) updated	3 3 new	9	by charles.beal Oct 15 2012 - 7:57am	by Aaron Van Pelt 19 hours 8 min ago
Software upgrade? updated	3 3 new	24	by isabellamariani Oct 11 2012 - 1:48am	by Aaron Van Pelt 20 hours 46 min ago
cleaning the vaporizer updated	7 7 new	57	by Claire Normandeau Sep 27 2012 - 7:06am	by marion 1 day 8 hours ago
Computer startup issue updated	4 2 new	213	by Aaron Van Pelt Nov 16 2010 - 3:13pm	by Aaron Van Pelt 1 day 13 hours ago

The left sidebar contains sections for "Literature & Publications", "Application Notes", and "Whitepapers", each with several links to technical documents and articles.