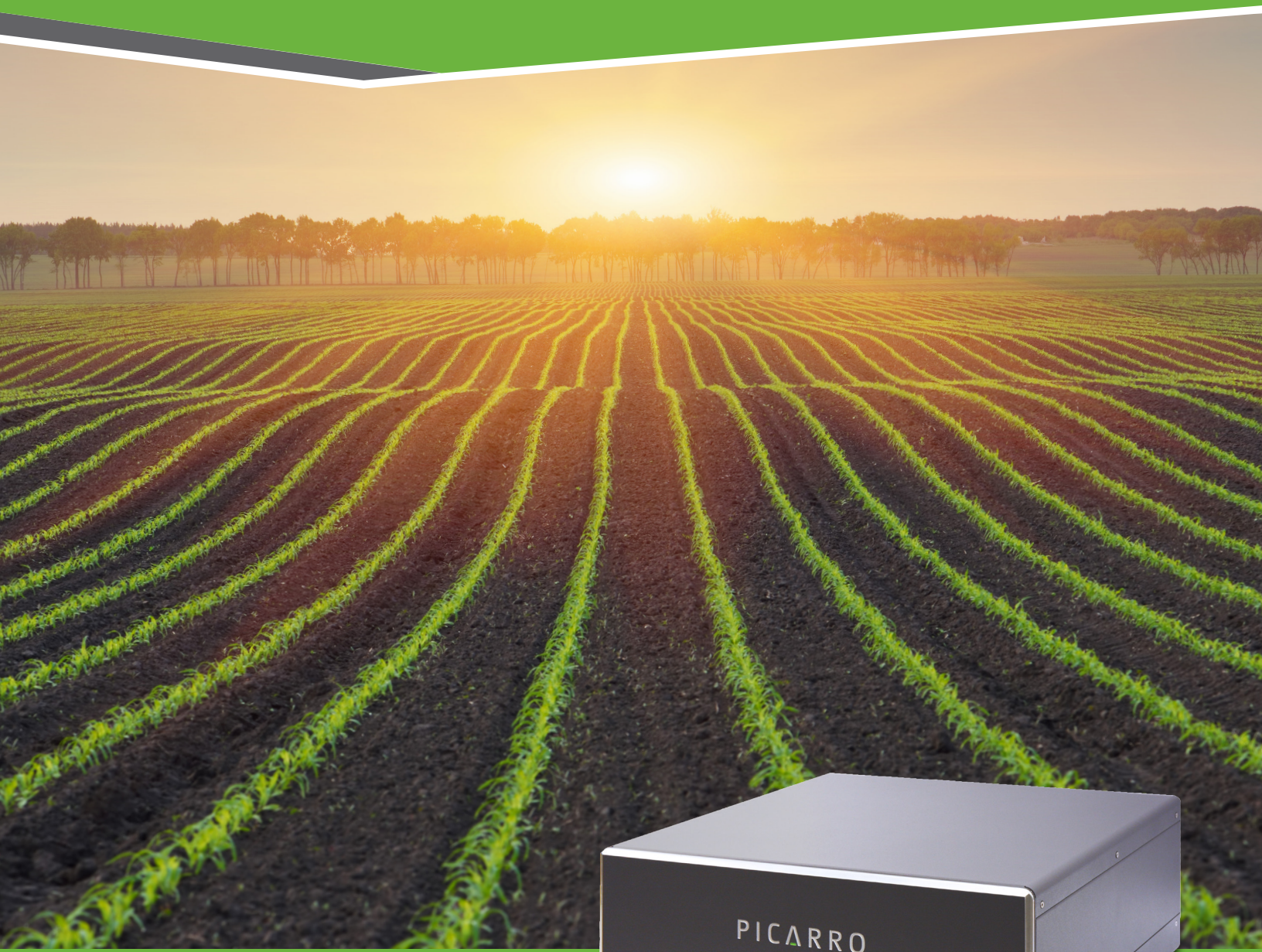


High-Precision Carbon Isotope Analysis Systems

Quickly and accurately measure $\delta^{13}\text{C}$ in CO_2 and CH_4 anywhere



PICARRO

ADVANCING OUR UNDERSTANDING OF BIOCHEMICAL PROCESSES WITH PRECISION CARBON ISOTOPE ANALYSIS

Determining the isotopic composition of carbon in a compound is a critical capability in many scientific, industrial, and environmental applications. Isotopic data can be used to:

- gain insights into how carbon is exchanged between the atmosphere and ecosystems
- monitor carbon geo-sequestration sites
- verify food origin and authenticity
- substantiate supply chain integrity
- detect the carbon source in dissolved carbonates
- identify and partition the sources of fugitive methane gas emissions

Picarro's Carbon Isotope Analysis Systems provide the high-quality, real-time, continuous measurements of $\delta^{13}\text{C}$ in CO_2 and CH_4 quickly and simply. Their small, light, robust design makes them ideal for lab and field work. And, with a comprehensive selection of compatible peripherals, the Picarro analyzers can process just about any type of sample.

HIGHLIGHTS

- Measure $\delta^{13}\text{C}$ in CO_2 and CH_4 simultaneously
- Excellent precision at a fraction of IRMS operating cost—less calibration, less maintenance, no consumables
- Pair with peripherals to measure $\delta^{13}\text{C}$ from many sample types
- Measure H_2O vapor and report dry mole fractions
- Field-deployable for real-time CH_4 emissions source attribution
- Small cavity (35 mL) for fast sample turnover time
- Low drift with outstanding temperature and pressure (T&P) stability



Carbon Isotope Analyzer Family

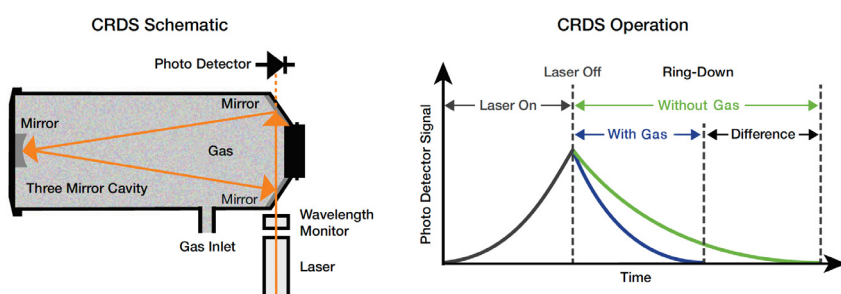
- G2131-*i* Isotope Analyzer
 - Measures $\delta^{13}\text{C}$ for CO_2 with 0.1‰ or better precision
- G2210-*i* Isotope Analyzer
 - Measures $\delta^{13}\text{C}$ for CH_4 and C_2H_6 -to- CH_4 ratio
- G2201-*i* Isotope Analyzer
 - Measures $\delta^{13}\text{C}$ in CH_4 and CO_2 simultaneously

COMPREHENSIVE SOLUTIONS FOR WIDE RANGE OF APPLICATIONS

Picarro's Carbon Isotope Analysis Systems are the gold standard measurement technology. Picarro systems can be deployed for applications ranging from atmospheric and ocean science research to food and beverage origin and authenticity, to measuring and determining the source of methane emissions at landfills, fracking sites, and abandoned oil and gas wells. Picarro's carbon isotope analysis solutions combine outstanding precision with reduced calibration requirements, minimal maintenance and consumables, all at a fraction of the operating cost of Isotope Ratio Mass Spectrometry (IRMS). This makes Picarro's solutions faster, easier, and more cost-effective, enabling efficient capture of the unique insights offered by stable isotope ratios.

PATENTED CRDS TECHNOLOGY ENSURES HIGH PRECISION AND LOW DRIFT

All Picarro analyzers are built on proven Cavity Ring-Down Spectroscopy (CRDS) technology. This sophisticated time-based measurement uses a laser to quantify spectral features of gas phase molecules in an optical cavity. A beam from a single-frequency laser diode enters a three-mirror cavity to create a continuous traveling light wave, as illustrated in the figure below. The laser is locked to the patented wavelength monitor to ensure spectral precision. When the laser is on, the cavity fills with circulating laser light. A fast photodetector senses a small amount of light emanating through one of the mirrors to produce a signal that is directly proportional to the intensity in the cavity.



Picarro's CRDS technology offers several advantages over Isotope Ratio Mass Spectrometry (IRMS). Picarro's unique CRDS technology relies on time-based measurements providing the highest precision and lowest drift. CRDS also allows for low flow and fast response which are required to achieve real-time, quality measurements. In addition, Picarro's patented wavelength monitor maintains the wavelength of the laser frequency and sequential sensitivity, providing uncompromised precision and accuracy over time in ambient conditions.

APPLICATIONS

- Carbon Cycling Studies
- Paleoclimatology
- Geology and Geochemistry
- Archaeology and Anthropology
- Food Authentication and Traceability
- Forensic Science
- Environmental Sciences
- Agricultural Research
- Biogeochemistry
- Oceanography
- Atmospheric Sciences
- Hydrology and Water Resources



SPECIALIZED CARBON ANALYSIS PERIPHERALS



Small Sample Introduction Module 2 (SSIM 2)

The Picarro A0314 Small Sample Introduction Module 2, or SSIM2, transforms Picarro continuously-sampling analyzers into instruments capable of measuring small, discrete gas samples, as small as 20 mL.

- Introduce samples via syringe or gas-bag
- Single sample or automatic processing of up to 8 samples using the Picarro 16-Port Manifold (A0311)
- Built-in dilution system enables optimal concentration targeting for isotopic analysis
- Automatically measure isotopic reference gases between samples

Compatibility:

- G2201-*i*
- G2131-*i*

Related Applications:

- Agricultural & Soil Science
- Ecology
- Health & Safety
- Petrochemical



Closed System Measurement Package

The Picarro A0701/A0702 Closed System Measurement Package enables Picarro analyzers to provide high-precision concentration and isotope ratio measurements for experiments conducted in closed, recirculating systems.

- Real-time, non-destructive concentration and isotope studies
- Have confidence in your results; minimal efflux and influx
- Ideal for small sample work; perfectly matched to our small cavity technology
- Rugged, robust analyzers for use in the field or in the lab

Compatibility:

- G2201-*i*
- G2131-*i*

Related Applications:

- Ecology
- Agricultural & Soil Science



Combustion Module (CM)

The Picarro A0201 Combustion Module enables $\delta^{13}\text{C}$ measurements of bulk samples - soils or liquid organic materials. The samples are combusted within the CM and the CO_2 that is produced flows to a Picarro analyzer to measure $\delta^{13}\text{C}$ for bulk stable isotope analysis (BSIA).

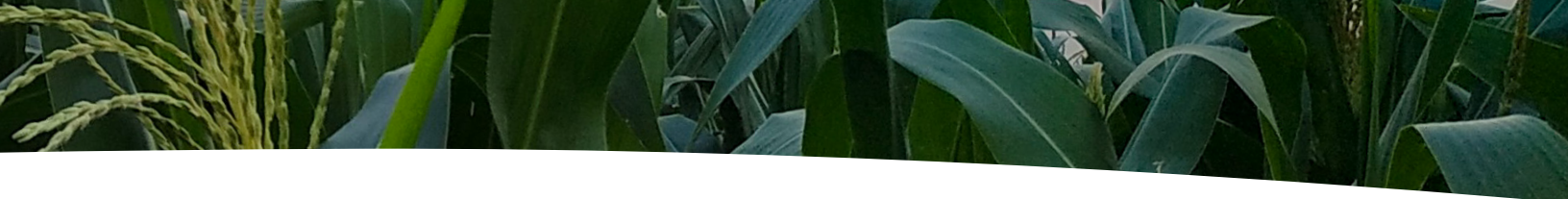
- The CM-CRDS system can automatically process up to 148 samples at a rate of one sample every 10 minutes
- The precision of the system is better than 0.3‰
- Control and data recording are managed by software on the Picarro analyzer

Compatibility:

- G2201-*i*
- G2131-*i*

Related Applications:

- Air Quality
- Ecology
- Agricultural & Soil Science
- Paleoclimatology
- Food & Beverage
- Petrochemical



Caddy™ Continuous Flow Interface

The Picarro A2100 Caddy Continuous Flow Interface connects commercially available solid and liquid bulk sample preparation instruments—including the Picarro Combustion Module—to Picarro analyzers for high-precision carbon isotope (^{13}C) measurements.

- Fully automated for high-throughput operation
- Low-cost, simple operation
- Laboratory and field deployable

Compatibility:

- G2201-*i*
- G2131-*i*

Related Applications:

- Air Quality
- Ecology
- Agricultural & Soil Science
- Paleoclimatology
- Food & Beverage
- Petrochemical
- Hydrology
- Ocean Science



Gas Autosampler

The Picarro Gas Autosampler streamlines discrete sample analysis when paired with Picarro gas analyzers. Featuring a 150-position-vial rack for 12mL headspace vials, this system enables the analysis of up to 160 samples per day.

- Complete solution for automated analysis
- Compatible software for seamless operation
- Sample analysis conducted automatically with data reported

Compatibility:

- G2201-*i*
- G2131-*i*
- G2210-*i*

Related Applications:

- Air Quality
- Ecology
- Agricultural & Soil Science
- Health & Safety
- Petrochemical
- Hydrology
- Ocean Science



AutoMate Prep Device

When a Picarro $\delta^{13}\text{C}$ -CO₂ analyzer is coupled with an AutoMate A0304 sample preparation device, the system provides $\delta^{13}\text{C}$ measurements of the dissolved inorganic carbon in water samples or $\delta^{13}\text{C}$ in solid carbonate samples.

- Fast, fully automatic acidification of carbonate and DIC samples
- Low, consistent blanks
- Low downtime between samples
- Small dead volume

Compatibility:

- G2201-*i*
- G2131-*i*

Related Applications:

- Ocean Science
- Paleoclimatology
- Petrochemical



SPECIFICATIONS

G2201- <i>i</i> Performance Specifications			
Measurements	CO ₂	CH ₄	H ₂ O
δ ¹³ C Precision in CO ₂ mode*	<0.12‰	NA	NA
δ ¹³ C Precision in CH ₄ mode*	NA	HP [†] : <0.8‰ HDR ^{††} : <0.4‰	NA
δ ¹³ C Precision in Dual mode*	<0.16‰	HP [†] : <1.15‰ HDR ^{††} : <0.55‰	NA
Concentration Precision in CO ₂ mode**	200 ppb (¹³ C)/10 ppb (¹² C)	50 ppb (¹² C)	100 ppm
Concentration Precision in CH ₄ mode**	1 ppm (¹² C)	HP [†] : 5ppb (¹² C)/1ppb (¹³ C). HDR ^{††} : 50ppb (¹² C)/10ppb (¹³ C).	100 ppm
Concentration Precision in Dual mode**	200 ppb (¹³ C)/10 ppb (¹² C)	HP [†] : 5ppb (¹² C)/1ppb (¹³ C). HDR ^{††} : 50ppb (¹² C)/10ppb (¹³ C).	100 ppm
δ ¹³ C Max Drift in CO ₂ mode***	<0.6‰	NA	NA
δ ¹³ C Max Drift in CH ₄ mode***	NA	HP [†] and HDR ^{††} : <1.15‰ at 10ppm CH ₄	NA
δ ¹³ C Max Drift in Dual mode***	<0.6‰	HP [†] and HDR ^{††} : <1.15‰ at 10ppm CH ₄	NA
Dynamic Range	CO ₂	CH ₄	H ₂ O
Guaranteed Spec Range in CO ₂ mode	380–2,000 ppm	1.8–500 ppm	0–2.4%
Guaranteed Spec Range in CH ₄ mode	200–2,000 ppm	HP [†] : 1.8–12 ppm HDR ^{††} : 10–1,000 ppm	0–2.4%
Guaranteed Spec Range Dual mode	380–2,000 ppm	HP [†] : 1.8–12 ppm HDR ^{††} : 10–500 ppm	0–2.4%

G2131- <i>i</i> Performance Specifications			
Measurements	CO ₂	CH ₄	H ₂ O
δ ¹³ C Precision*	0.1‰ at >380 ppm CO ₂	NA	NA
Concentration Precision**	200ppb (¹³ C)/10ppb (¹² C)	50ppb (¹² C)	100 ppm
δ ¹³ C Max Drift***	<0.5‰	NA	NA
Dynamic Range	CO ₂	CH ₄	H ₂ O
Guaranteed Spec Range	380–2,000 ppm	0–500 ppm	0–2.4%

G2210- <i>i</i> Performance Specifications				
Measurements	CO ₂	CH ₄	H ₂ O	C ₂ H ₆
δ ¹³ C Precision*	NA	0.5–1‰	NA	NA
Concentration Precision**	<200ppb	<0.1 ppb	NA	<1 ppb
Dynamic Range	CO ₂	CH ₄	H ₂ O	C ₂ H ₆
Guaranteed Spec Range	300–2,000 ppm	1.5–30 ppm	NA	0–100 ppm

* 1-σ, 5 min average

** 30 sec, 1-σ

*** Peak-to-peak, 1-hour average interval over 24 hours at STP

† High Precision mode

†† High Dynamic Range mode

CONCENTRATION AND CARRIER GAS MODES

	CO ₂ Modes			CH ₄ Modes		Isotopic Enrichment	Carrier Gas Support		Additional Gas Support
Supported Isotope	δ ¹³ C	δ ¹³ C	δ ¹³ C	δ ¹³ C	δ ¹³ C	δ ¹³ C in CO ₂			
Supported Range	Down to 200 ppm	380 – 2,000 ppm	2,000–4,000 ppm	1.8–12 ppm	10–1,000 ppm	Enriched up to 6,500‰	Air	N ₂	
G2131- <i>i</i>	*S0511	✓	*S0507, Air *S0509, N ₂	NA	NA	*S0506	✓	*S0512	NA
G2201- <i>i</i>	*S0511 CO ₂ only mode	✓	*S0507, Air *S0509, N ₂ CO ₂ only mode	✓	✓	*S0506 CO ₂ only mode	✓	*S0512 CO ₂ only mode	NA
G2210- <i>i</i>	NA	NA	NA	✓	NA	NA	✓	NA	C ₂ H ₆

Fields marked with (✓) represent modes that come pre-installed on an analyzer.
Fields marked with (*) represent a selection that must be made at the time of purchase.

About Picarro

Picarro is the leading provider of enhanced optical spectroscopy analytical solutions that empower the world with timely, trusted, and actionable data. Picarro technology plays a critical role in a broad spectrum of scientific and industrial applications. Scientists use our instruments to measure greenhouse gases (GHGs) and stable isotopes to advance environmental research. Facility operators leverage our monitoring systems to ensure regulatory compliance and create safer

workplaces and communities. Natural gas distributors are charting a path to Net Zero with Picarro. Semiconductor manufacturers integrate Picarro instruments into their production processes to control costs and improve yield. With more than 25 years in business, a dedication to customer success, and comprehensive support and services, Picarro is more than a technology provider, we're a trusted partner in an ever-expanding number of markets.

Visit picarro.com to learn more about products, peripherals and applications.

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