POSTER: **A43N - 1709**

HIGH-PRECISION CONTINUOUS AND REAL-TIME MEASUREMENT OF OXYGEN USING CAVITY RING-DOWN SPECTROSCOPY FOR PHOTOSYNTHETIC LIGHT AND CO_2 RESPONSE CURVES

Magdalena Hofmann[1], David Kim-Hak[1], John Hoffnagle[1], Doug Lynch[2], Mark Johnson[2]

[1]Picarro, Inc., 3105 Patrick Henry Drive, Santa Clara, California, USA

[2]LI-COR Biosciences, Inc, 4647 Superior Street, Lincoln, Nebraska, 68504, USA

1. ABSTRACT

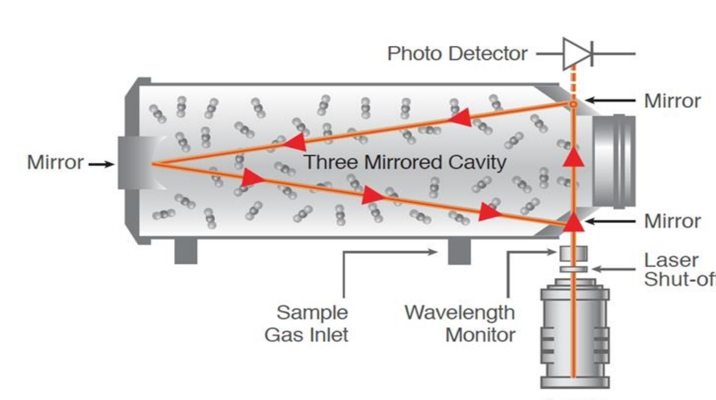
Photosynthesis is a complex process that consumes carbon dioxide and water to produce oxygen and glucose. Studies to investigate leaf-level photosynthetic activity have been conducted using systems that control certain parameters such as light intensity or partial pressure of CO_2. For instance, the LI-COR LI-6800 Portable Photosynthesis System enables the user to control and measure light, temperature, CO_2 and water vapor concentrations. Measurement of O_2 fluxes concurrent with CO_2 exchange and other parameters is a technical challenge since a very high level of precision on a large O_2 background is required. Only few analytical methods including mass spectrometry, fuel cell, ultraviolet and paramagnetic cells can achieve the required high-precision O_2 analysis.

Here we present new developments of a high-precision gas analyzer that utilizes the technique of Cavity Ring-Down Spectroscopy to measure oxygen concentrations. Its compact and rugged design combined with high-precision and long-term stability allow the user to deploy the instrument in the field for continuous monitoring of atmospheric oxygen level. Measurements have a 1-σ 5-minute averaging precision of 1-2 ppm for O_2 over a dynamic range of 0-25%. We present collaborative work with LI-COR where we coupled the Picarro G2207-i O_2 analyzer with the LI-6800 Portable Photosynthesis System to enable O_2 analysis for laboratory studies of photosynthesis. To validate the setup, we conducted light and CO_2 response experiments.

2. INSTRUMENTATIONS

CRDS Technology and Picarro G2207-*i* Analyzer

Cavity Ring-Down Spectroscopy (CRDS) Technology utilizes the unique infrared absorption spectrum of gas-phase molecules to quantify the concentration of (and sometimes isotopes of) H_2O, CO_2, CH_4, N_2O, CH_2O, NH_3.



CRDS Features:

- Small 3-mirrored cavity ~ 35 cc
- Long effective path-length (> 10 km)
- Time-based measurement
- Laser is switched on and off, and scanned across wavelengths

The Picarro G2207-*i* analyzer uses the CRDS technology to measure continuously $\delta^{18}O$ in O_2 and O_2 concentrations.

G2207-*i* Performance Specifications:

[O₂] Mode	
Precision, dry [O₂] at ambient concentration (1-σ, 5 sec/5 min, at 21% O₂)	<20 ppm/<2 ppm
Max Drift at STP O₂ (over 24 hrs, peak-to-peak, 1 hr interval average, at 21% O₂)	<6 ppm
[O₂] Operating Range	5–25%
Precision [H₂O] (1-σ, 5 sec)	5 ppm + 0.1% of reading

LI-6800 Portable Photosynthesis System

The LI-COR LI-6800 Portable Photosynthesis System probes the carbon fixation reactions of photosynthesis by calculating fluxes for CO_2 (assimilation) from the difference in measured concentrations of CO_2 and H_2O entering and exiting a leaf cuvette.

- Flow control
- CO_2 control
- Water vapor control
- Temperature control
- CO_2 analysis (IRGA)
- H_2O analysis (IRGA)
- Fluorometer

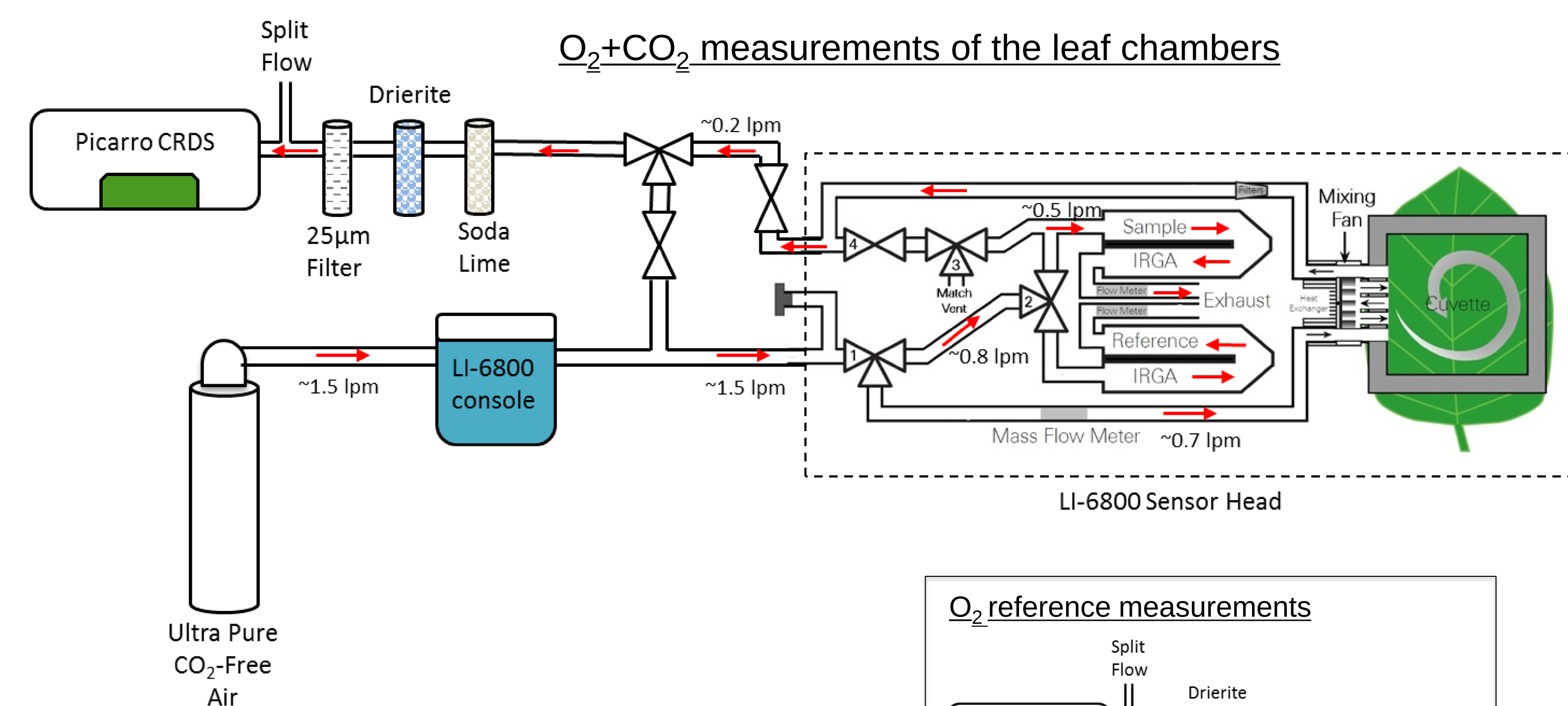
REFERENCES

[1] Von Caemmerer. Biochemical Models of Leaf Photosynthesis. CSIRO publishing, 2000.

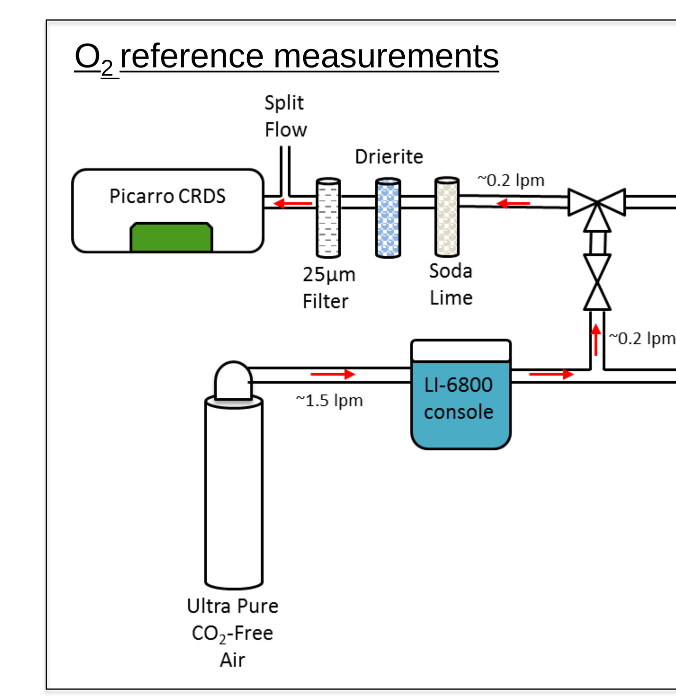
[2] Ruuska, Badger, Andrews, and Von Caemmerer, Photosynthetic electron sinks in transgenic tobacco with reduced amounts of rubisco: Little evidence for significant Mehler reaction, *Journal of Experimental Botany* 51, 2000: 357-68

3. METHOD

Flow configurations



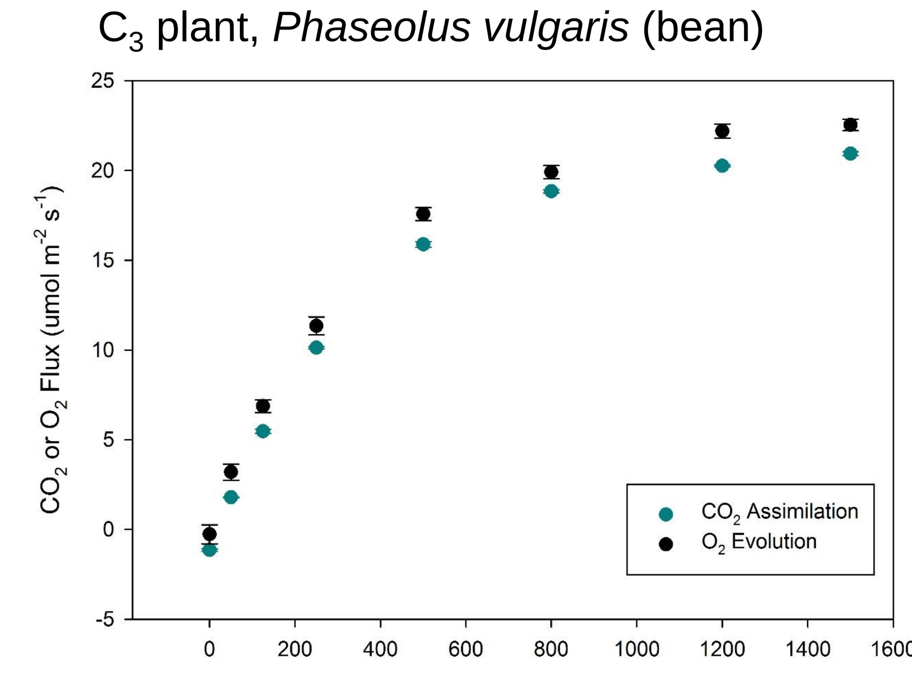
In order to reduce the uncertainty in CO_2 and O_2 gas exchange fluxes it is best to operate the setup with a large leaf area (6x6cm chamber) and low flow rate.



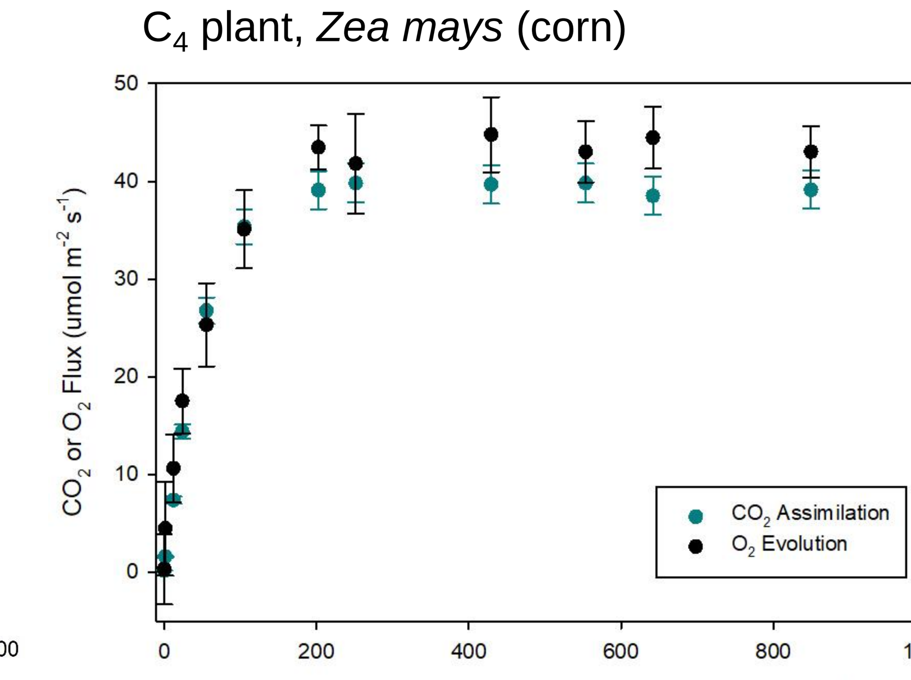
4. RESULTS

Light-response and CO_2 Response curves

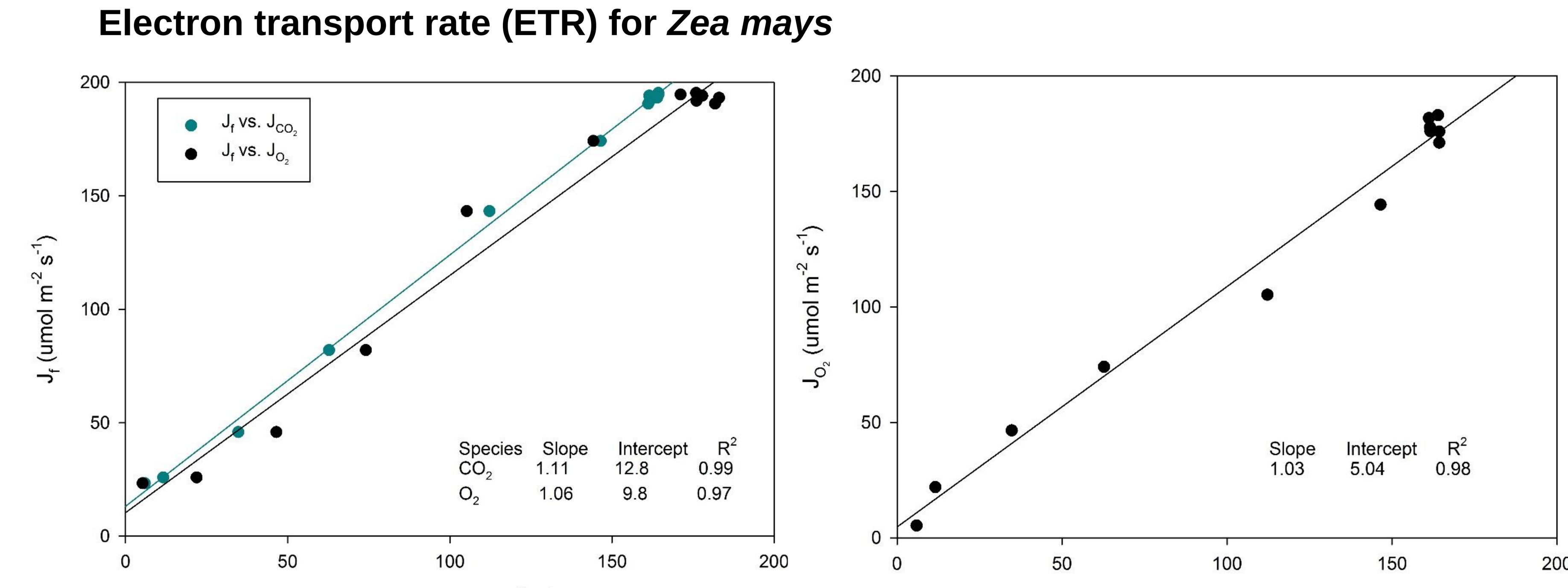
C_3 plant, *Phaseolus vulgaris* (bean)



C_4 plant, *Zea mays* (corn)



Electron transport rate (ETR) for *Zea mays*



5. CONCLUSION

- High-precision continuous and real-time measurement of O_2 with the Picarro G2207-i (<2ppm 1-σ uncertainty with 300 seconds averaging)
- Straightforward coupling of the G2207-i O_2 analyzer and the LI-COR LI-6800 Portable Photosynthesis System for combined O_2 and CO_2 measurements for leaf-level physiological research
- Light response curves for the C_3 plant *Phaseolus vulagris* (bean) and CO_2 response curve for the C_4 plant *Zea mays* (corn) are in line with expectations (expected stoichiometry for CO_2:O_2 is about 1, see [1, 2])
- Electron transport rates (ETR) for *Zea mays* from fluorescence measurements and derived from CO_2 and O_2 gross fluxes agree well.

Interested in learning more?

- Contact Magdalena Hofmann (mhofmann@picarro.com)
- Visit www.picarro.com.
- Visit www.licor.com/env