Laser-based gas analyzer for the direct measurement of trace hydrogen (H_2) and methane (CH_4) in ambient air

Mark Johnson, Siqin He, Katia Bonne

LI-COR, Inc., 4647 Superior Street, Lincoln, NE USA
(contact: mark.johnson@licor.com)

Introduction

The pursuit of hydrogen as a lower-carbon energy source benefits from in-field hydrogen measurements. Applications include:

- Exploration for natural (white or gold hydrogen) or stimulated hydrogen sources
- Fugitive emission monitoring near hydrogen production, distribution, and point-of-use
- Predicting environmental impacts from, and resilience to, potentially increased hydrogen concentrations in the atmosphere

We present a novel laser spectroscopy instrument based on **Optical Feedback - Cavity Enhanced Absorption Spectroscopy (OF-CEAS)** for direct measurements of trace hydrogen (H_2) and methane (CH_4) in an air matrix. This is a direct optical measurement which does not rely on electrochemical reactions or catalytic conversion to other species.

Performance Highlights

H_2 Measurements

Range: 0 to 2.5%

Precision (1σ) at 10 ppmv:

5 ppm at with 1 s averaging

3 ppm at with 5 s averaging

CH_4 Measurements

Range: 0 to 2.5%

Precision (1σ) at 2 ppmv:

0.5 ppm with 1 s averaging

0.25 ppm with 5 s averaging

T90 Response Time (H_2 and CH_4):

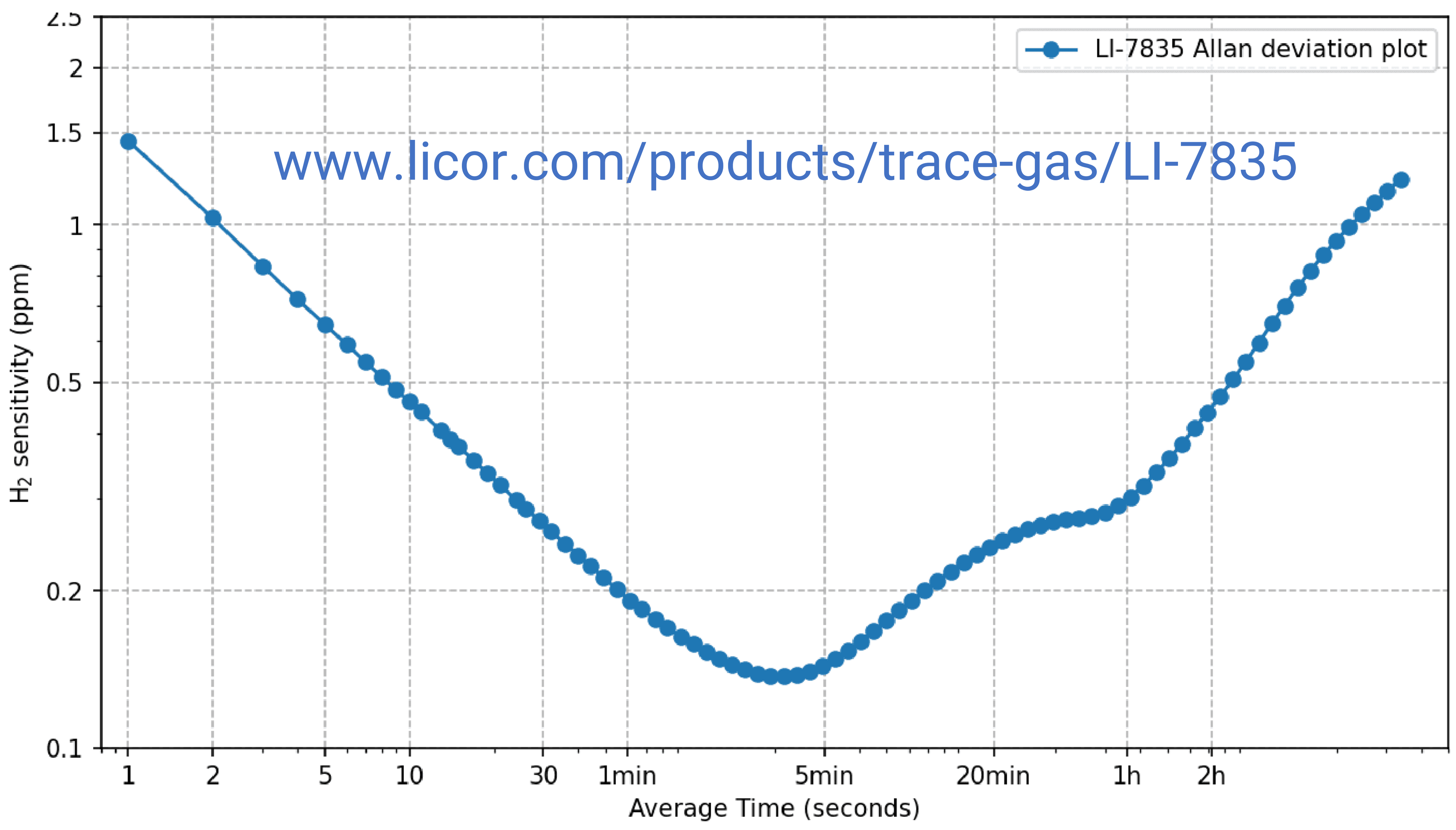
< 3 seconds

Data Output Rate:

1 Hz

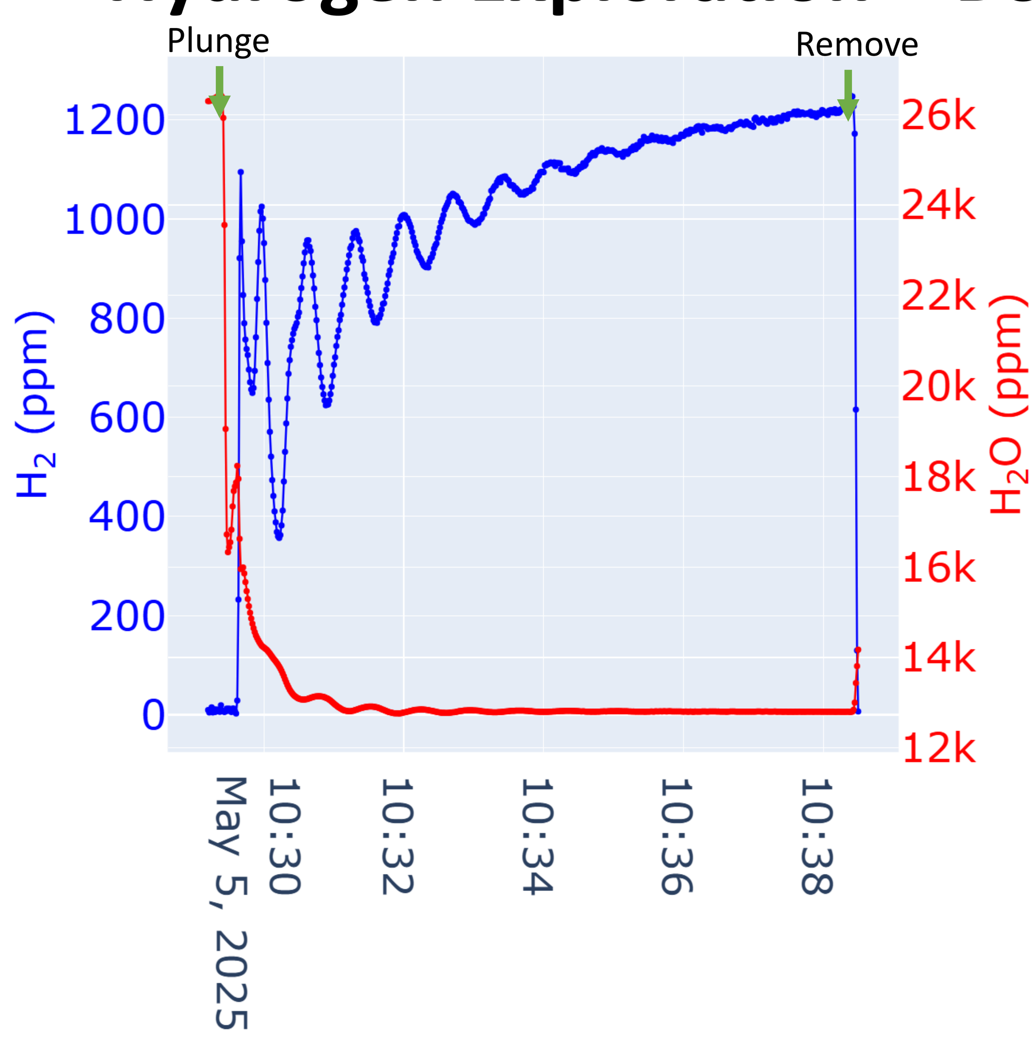
Technology compares:

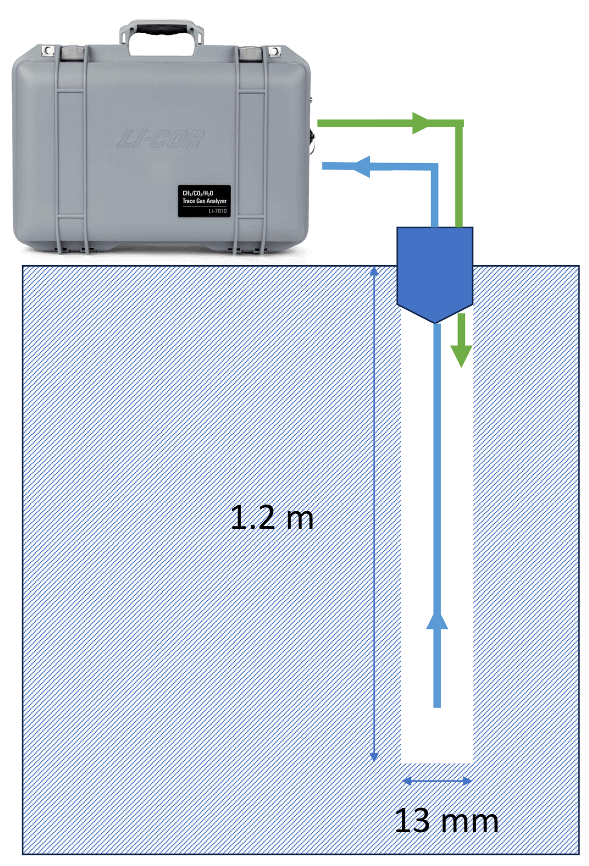
- Faster response time and higher dynamic range than most electrochemical sensors
- Better specificity than thermal conductivity-based sensors
- H_2O vapor compensation and reporting of **dry mole fractions**



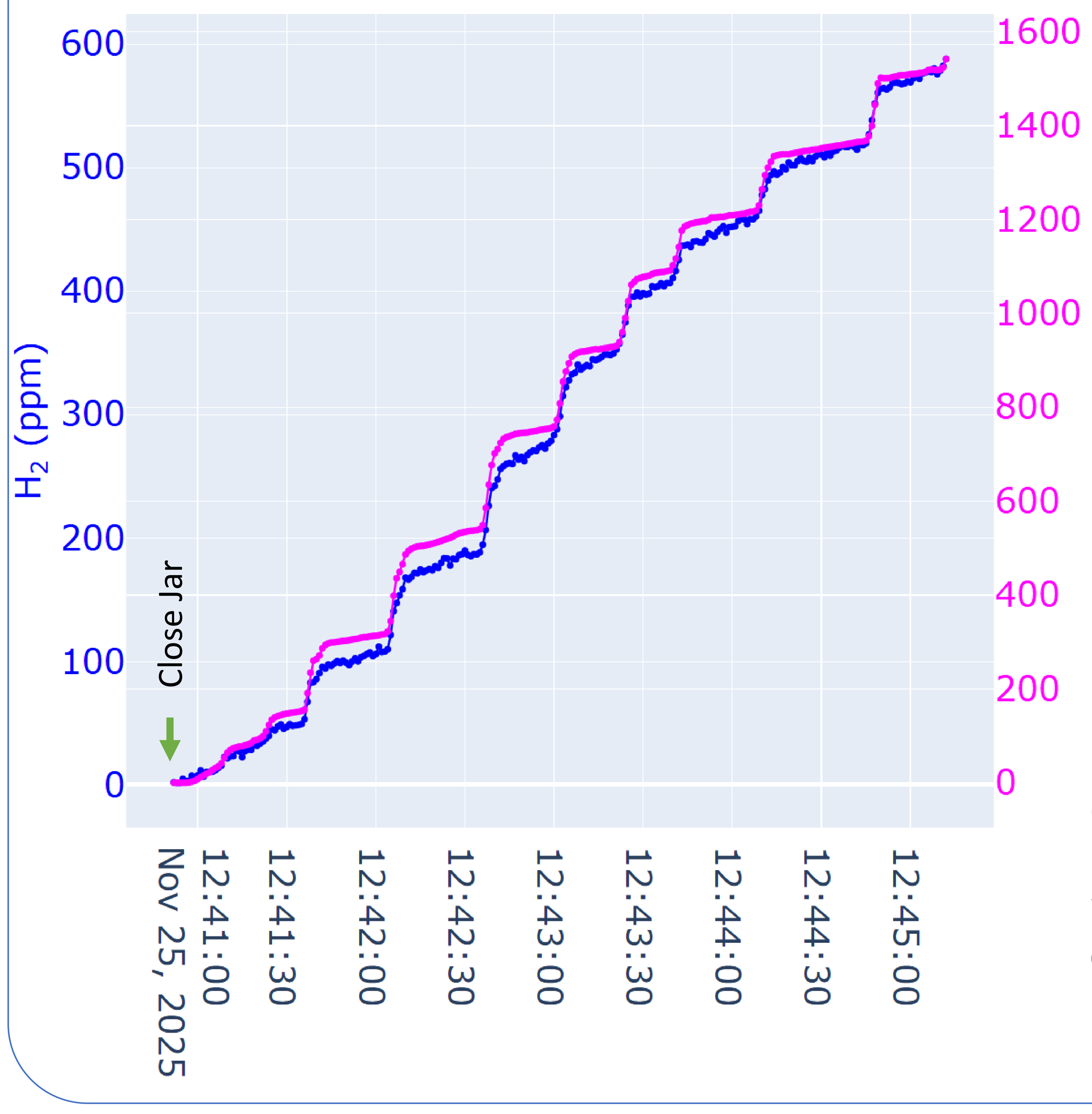
Allan Deviation: Dry tank gas of 498.1 ppmv (± 2%) H_2 in air

Hydrogen Exploration – Borehole Sampling





Hydrogen Exploration – Well Water Sampling

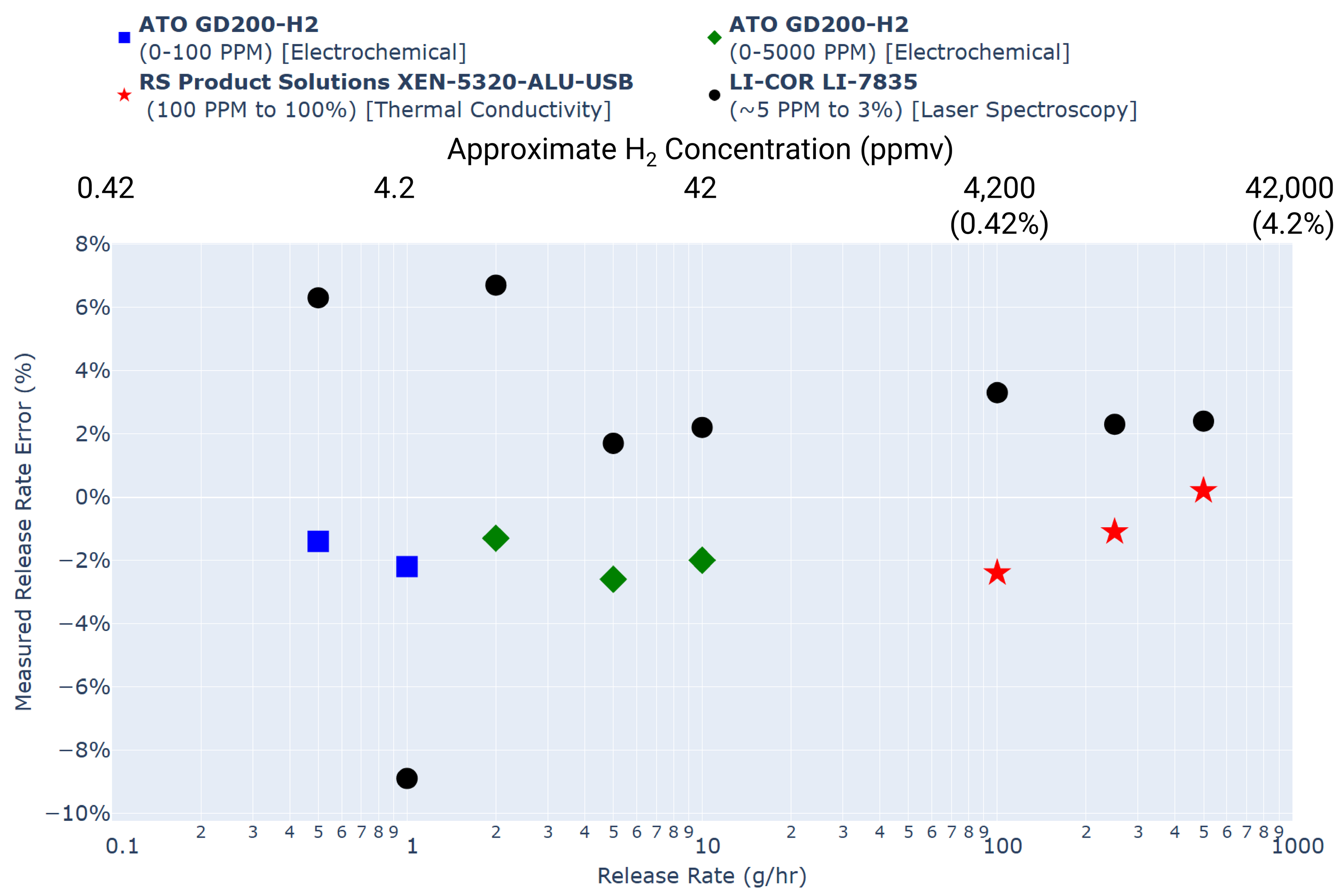


"Swirling" of jar produces step-changes in headspace concentrations

Leak Detection And Repair (LDAR)

West Virginia University

Researchers at WVU evaluated a range of sensing technologies for a hydrogen full flow sampling system (H2-FSS) to quantify H_2 emissions from hydrogen refueling stations & fuel cell vehicle exhaust: **electrochemical** sensors, **thermal conductivity** sensors, and a **laser spectroscopy** sensor. www.licor.com/blog/



Laser spectroscopy offers a dynamic range of 3-orders of magnitude, previously only possible with multiple electrochemical and thermal conductivity sensors.

Derek Johnson, et al. (2026), unpublished manuscript.

Conclusions

- Laser-absorption spectroscopy measurements of hydrogen have unique advantages of **specificity, rapid response time** (T90 < 3 seconds) and **high dynamic range** (a few ppmv to 2.5%).
- H_2 and CH_4 concentrations are **corrected for water vapor dilution** and reported in **dry mole-fraction.**
- Field applications to soil-gas measurements, water & soil headspace measurements, and leak detection were demonstrated.
- Simultaneous H_2 and CH_4 measurements are advantageous in biologic and geologic applications where both are often present

Acknowledgements

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