

Performance Evaluation of an Improved CRDS Ammonia (NH3) Analyzer

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INTRODUCTION

- Ammonia (NH₃) is the highest abundant alkaline gas in the atmosphere, and it makes major contribution to total reactive nitrogen to the environment and causes long-term climate change problems.
- NH₃ is also a hazardous pollutant with detrimental impacts on human health that demands strict control over personal exposure levels.
- NH₃ can be emitted from both natural and anthropogenic activities, such as soil and ocean volatilization, transportation, agricultural and industrial processes.
- High precision quantification of NH₃ is demanded for routine monitoring, regulation compliance, and migration needs.
- Accurate monitoring of NH₃ emissions can be challenging at low levels (ppb to ppm) due to the high reactivity of NH₃ and its tendency to adsorb to surfaces.
- Picarro introduced new SI2103 NH₃ analyzer to fit both academic and industrial applications.

OBJECTIVES

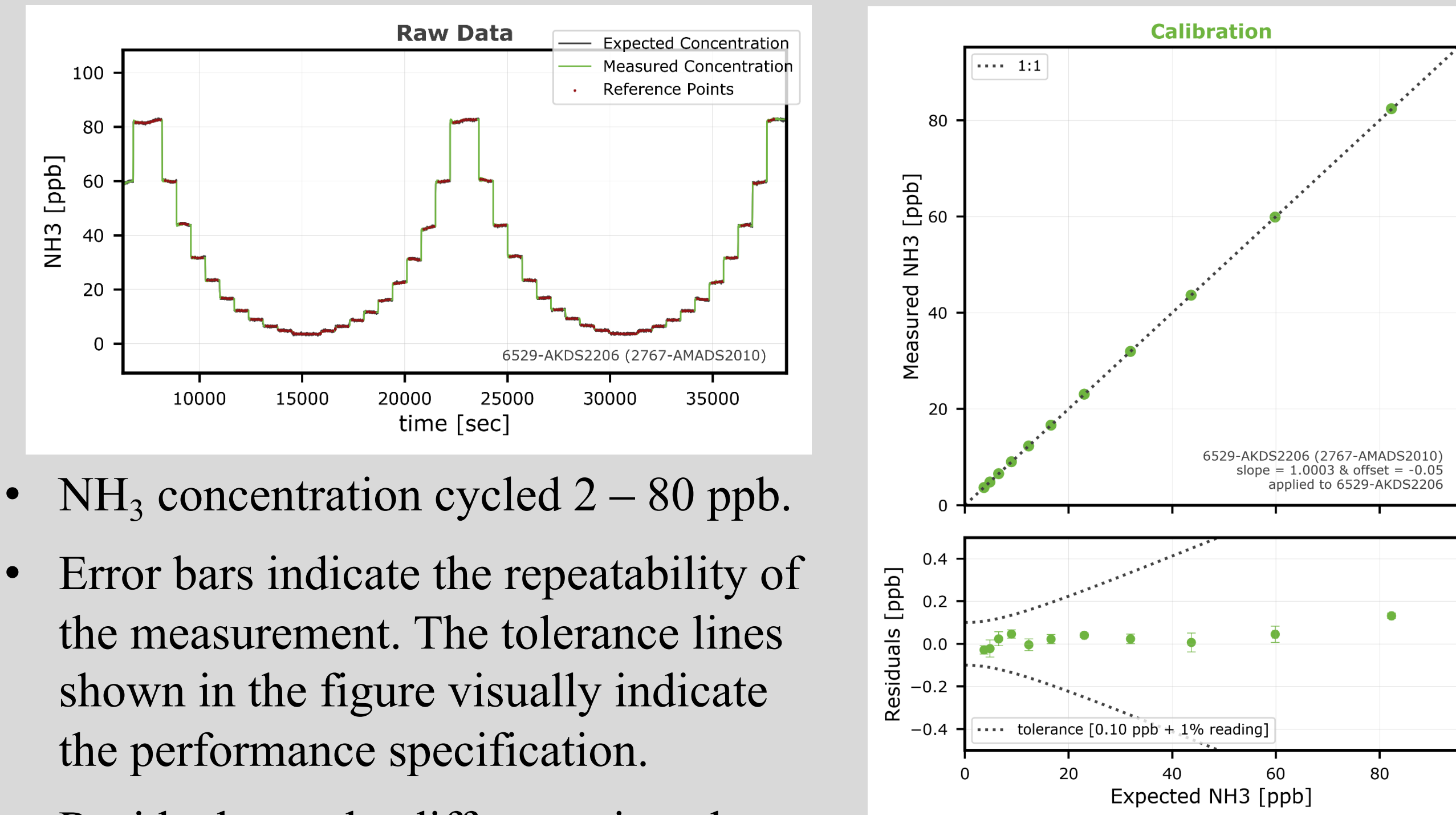
- Characterize the performance of the new SI2103 NH₃ analyzer.
- Investigate the effect of measured concentration on the analyzer's response times.
- Validate the extended operation range mode for NH₃ concentration up to 50 ppm.

REFERENCES

- Real-time, Online Monitoring of Ammonia and Greenhouse Gas Emissions in Livestock with Cavity Ring-Down Spectroscopy Picarro G2509 Analyzer, YAN, J. et al., AOGS 2023 Conference

Performance Characterization

Concentration Calibration



- NH₃ concentration cycled 2 – 80 ppb.
- Error bars indicate the repeatability of the measurement. The tolerance lines shown in the figure visually indicate the performance specification.
- Residuals are the difference in ppb between the measured concentration and the expected concentration.

Figure 1. Concentration calibration curve.

Detection Limit

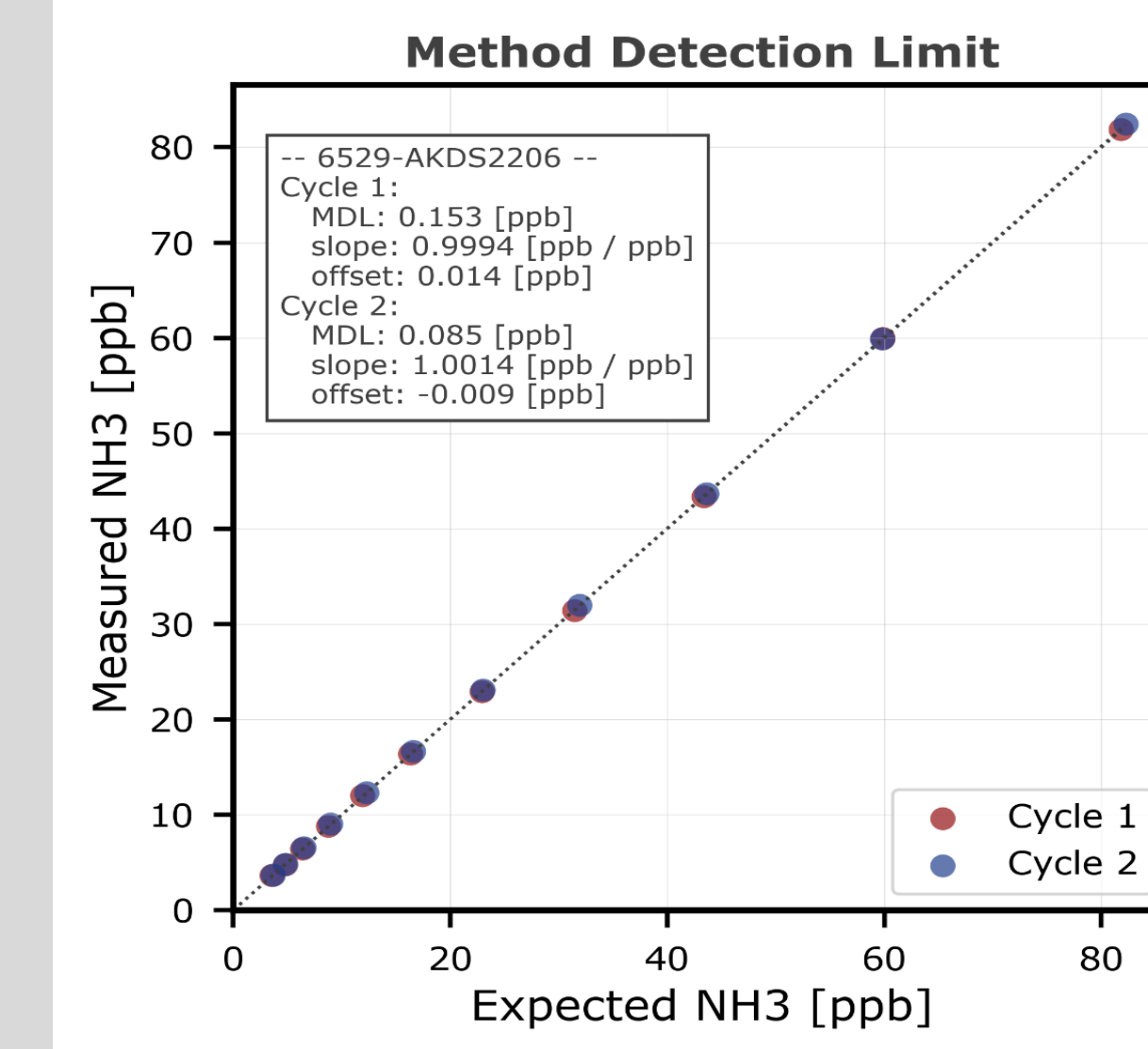


Figure 2. Detection limit of SI2103.

- Method detection limit (MDL) is calculated using linear regression analysis per SEMI C10-1109 standard.

T90/10 Response Time vs. Test NH3 Concentration

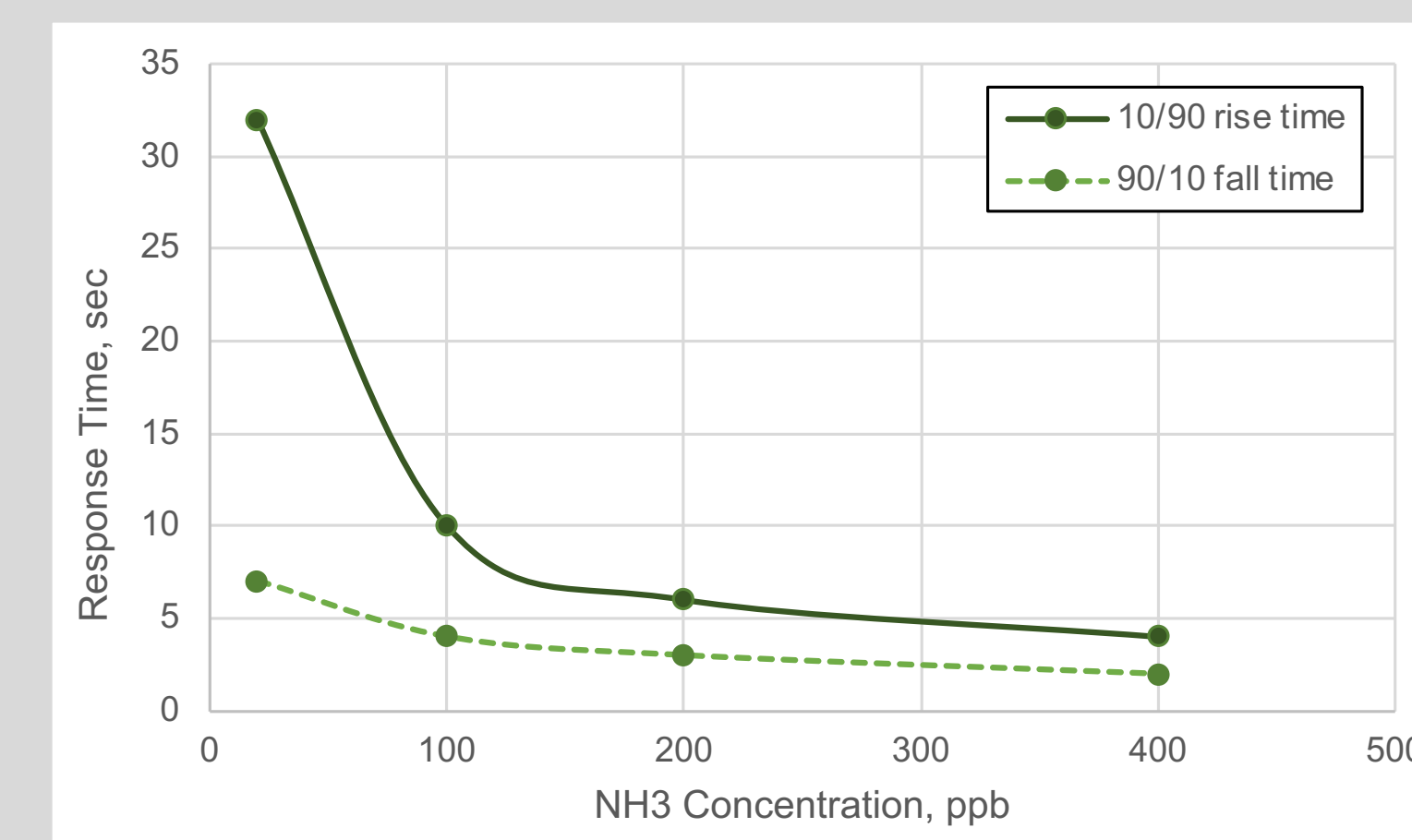
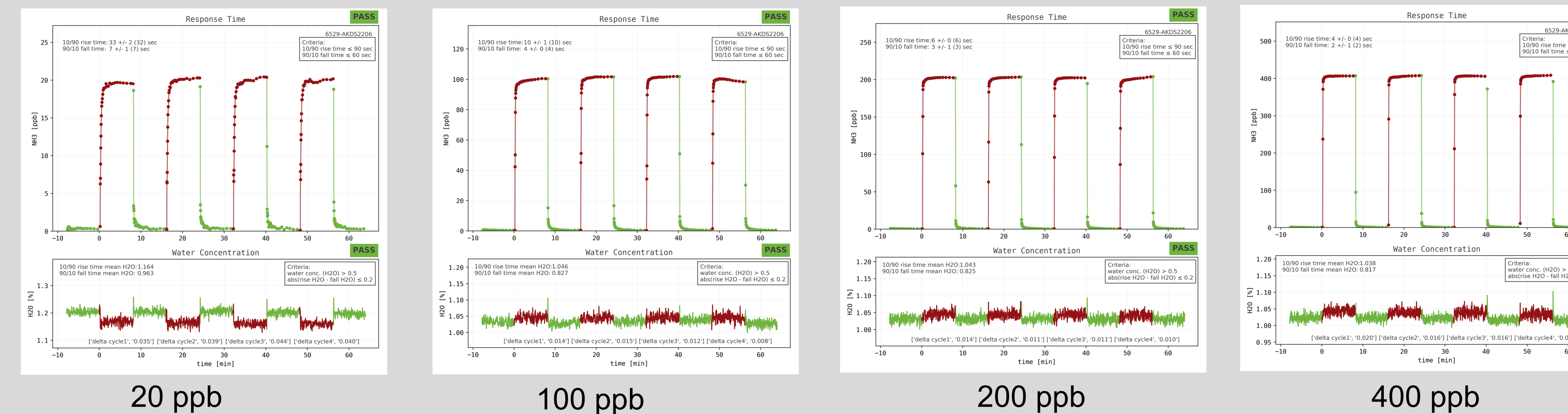


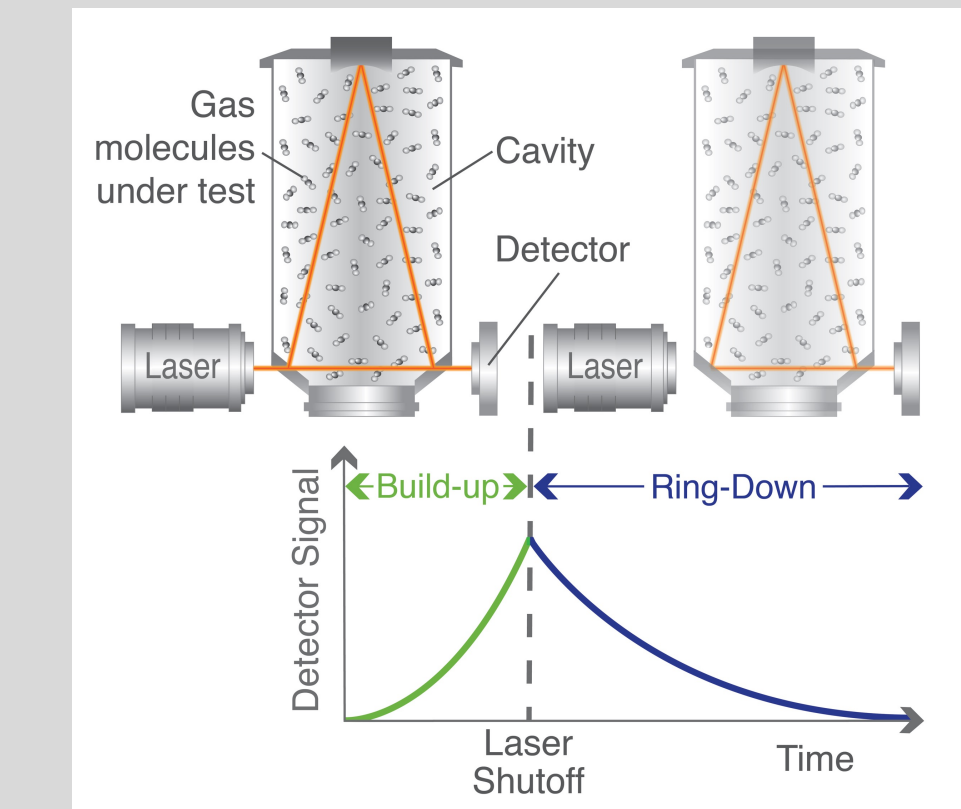
Figure 3. Response time varies with test concentration.

- Response time measurements are calculated using raw data from humid concentration challenges and humid zero concentrations.
- 10/90 rise time is defined as the length of time required to measure from 10% to 90% of the expected concentration.
- 90/10 fall time is defined as the length of time required to measure from 90% to 10% of the expected concentration.
- Both response times decrease as test concentration increases, with 20 ppb representing the longest response time among all test concentrations.

Picarro SI2103 NH₃ Analyzer



SI2103 NH₃ Analyzer



Cavity Ring-Down Spectroscopy (CRDS)

- Fast, continuous, real-time measurements with superb sensitivity, precision and accuracy
- Water (H₂O) and Carbon Dioxide (CO₂) measurements for correction and validation
- Small footprint, field or lab deployable with no consumables required

| SI2103 Performance Specifications | Guaranteed Performance*** |
|---|---------------------------|
| Lower Detection Limit (3σ, 100 sec) | 300 ppt |
| Zero Drift* (peak-to-peak, 50-minute average) | ±100 ppt |
| Precision (1σ, 10 sec) | ≤300 ppt |
| Precision (1σ, 100 sec) | ≤100 ppt |
| Measurement Interval** | <4 sec |
| Response Time (0–20 ppb) (Rise/Fall Time 10–90%/90–10%) | <1 min |
| Measurement Range | 0–10 ppm * |

* Extendable up to 0 – 50 ppm with optional extended NH₃ range mode.

Extended NH₃ Range Operation

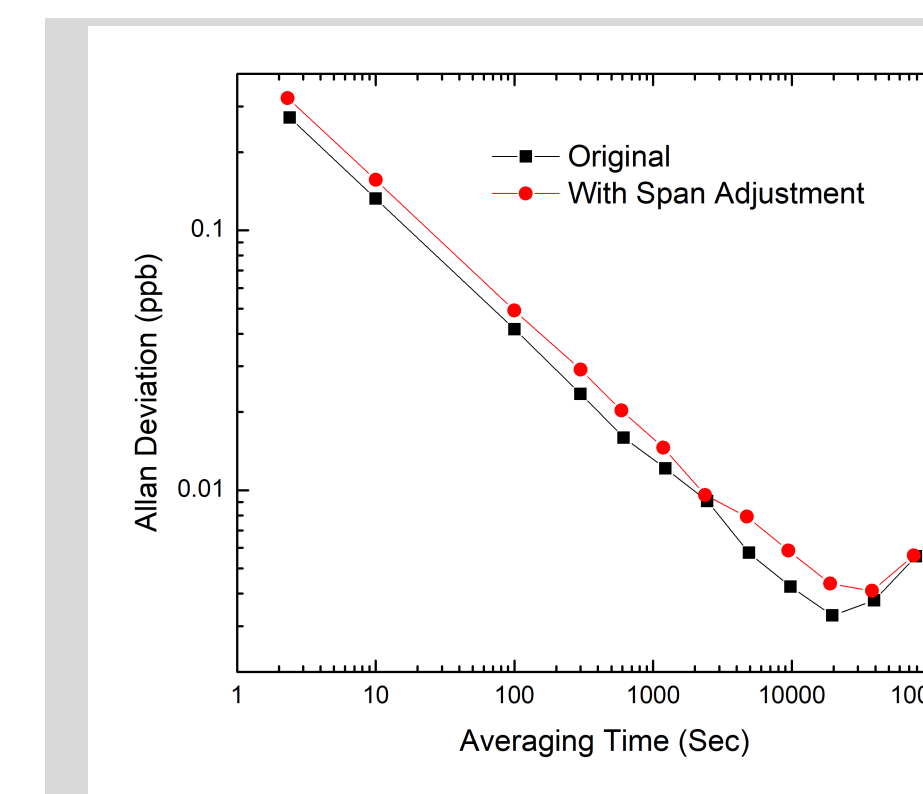


Figure 4. Allan variation for default and extended range configurations.

- The tradeoff for extended range operation is a slightly higher noise on the NH₃ measurement.
- Extended range performance: precision (10 Sec) ≤ 0.17 + 0.1% of reading and precision (300 Sec) ≤ 0.03 + 0.1% of reading. Overall, the performance is very close to the specification for the 5-minute performance under default configurations.

