

Leopold Seifert, Sumit Agarwal, Ajoy Ramalingam, Ravi Fernandes, Zhechao Qu

DOI: 10.7795/810.20240410

Introduction

- To improve **hydrogen**-related combustion processes, thorough knowledge of their underlying **reaction kinetics** is essential
- NO_x**-emissions (only harmful byproducts of H₂ combustion), need to be measured more accurately
- Time resolved **temperature**, **pressure** and **concentration** measurements are needed to validate kinetic models

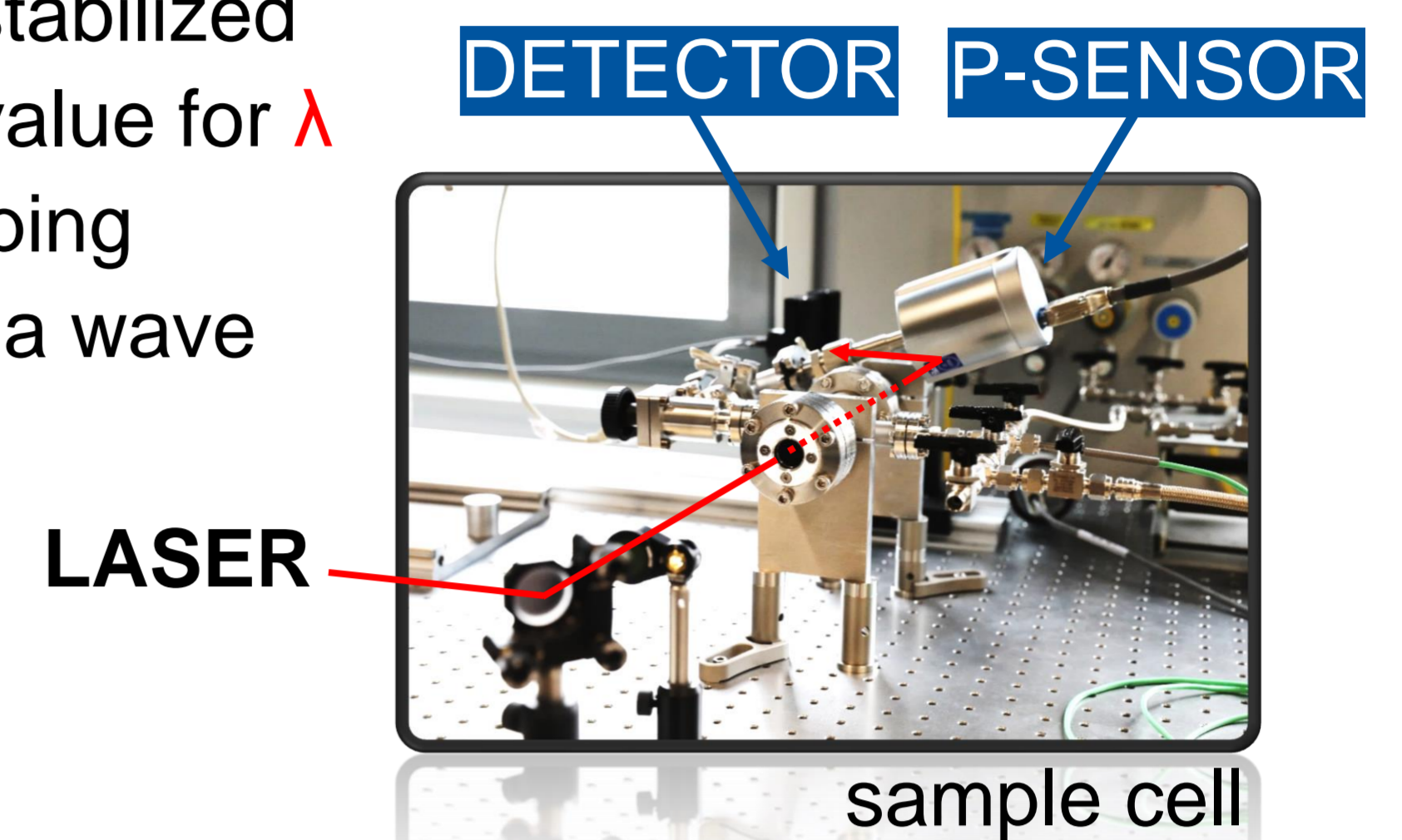
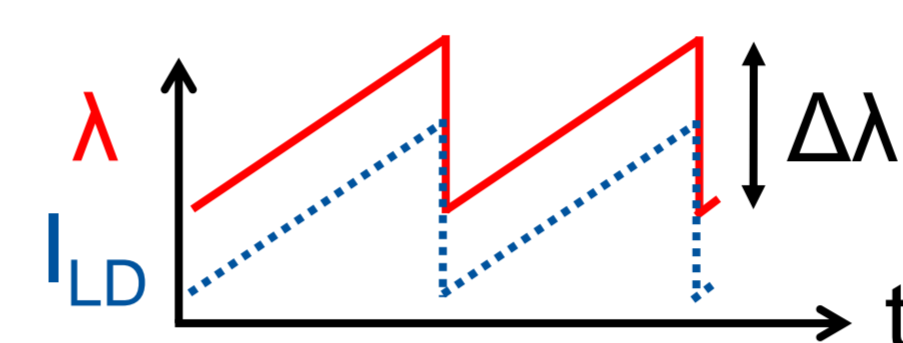
Solution:

Tunable Diode Laser Absorption Spectroscopy (TDLAS)

→ requires high quality traceable data of pressure broadening coefficients for foreign molecules (O₂, H₂, CO₂, Ar, He, N₂)

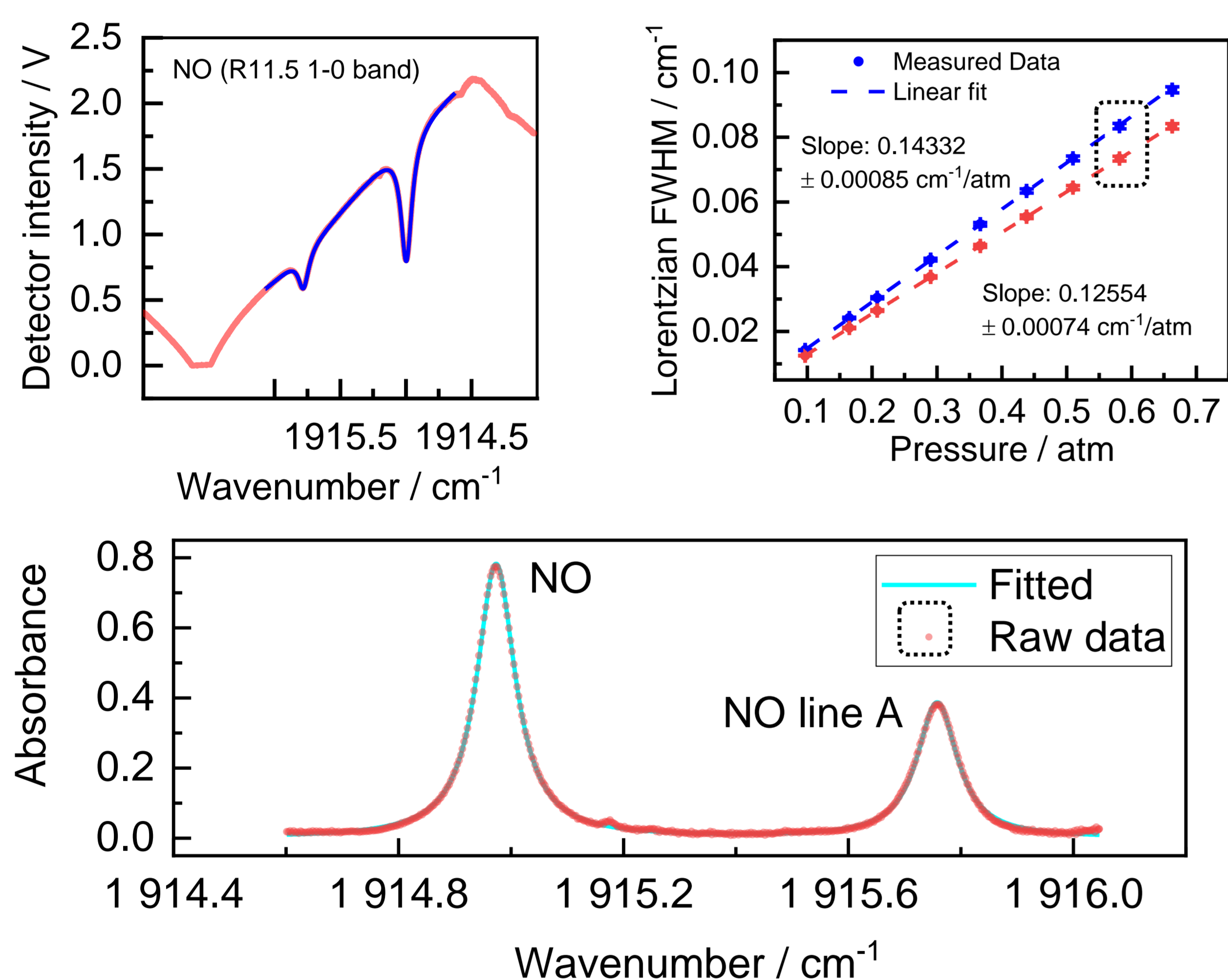
Setup

- single pass cell, absorption path **300 mm**, pressure **0 - 1 bar**
- Mid-IR range *Interband Cascade Lasers* (custom center WN)
- stable** single mode emission and **mode-hop-free**
- Laser diode temperature stabilized by TEC and set to target value for λ
- wavelength tuning by ramping the laser current I_{LD} using a wave function generator



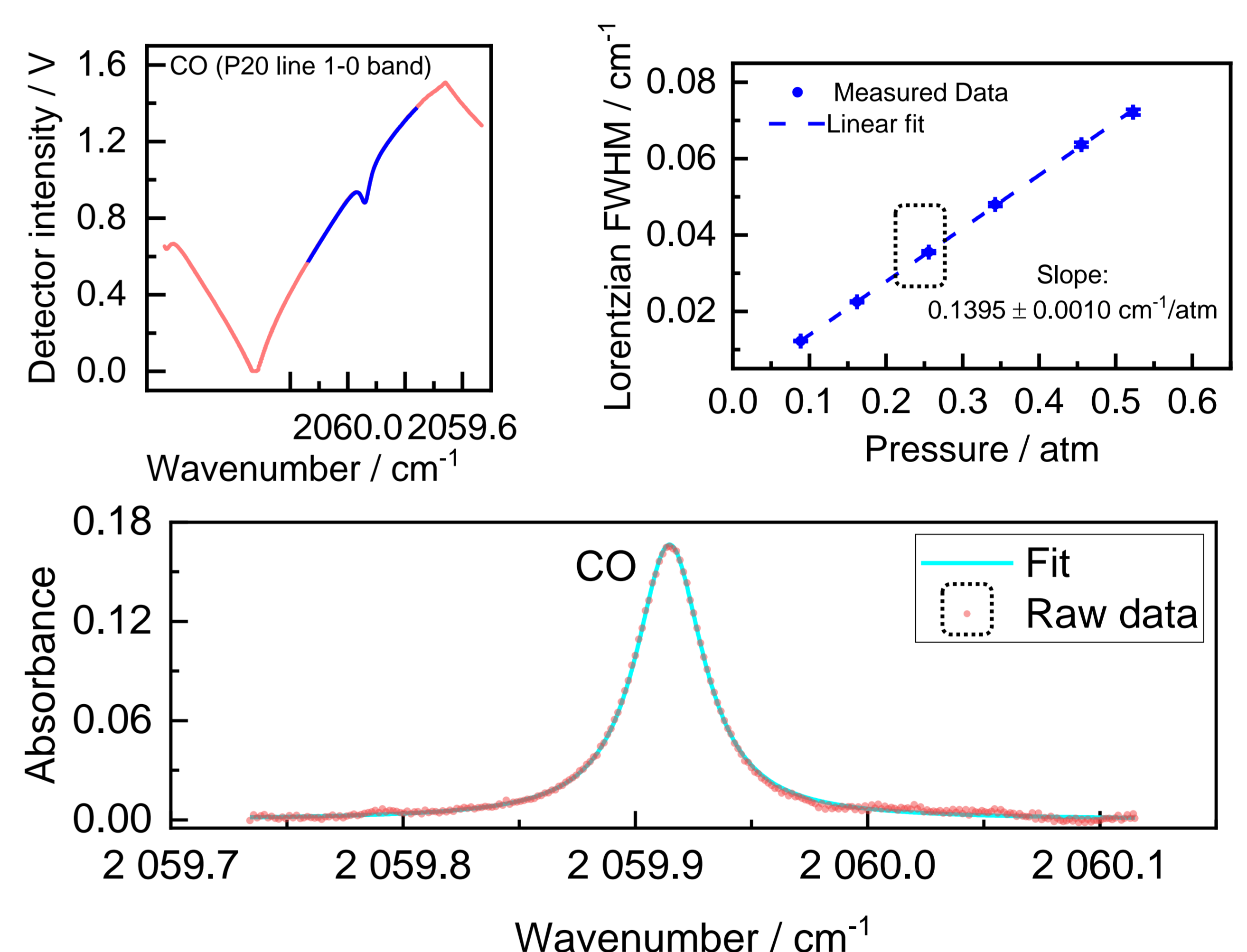
NO spectrum in H2

- center wavelength of Laser: 5220 nm
- 2 peaks** measured: NO [1914.9 cm⁻¹], NO (A) [1915.7 cm⁻¹]



CO spectrum in H2

- center wavelength of Laser: 4855 nm
- 1 line** measured: CO [2059.9 cm⁻¹]



Pressure Broadening Coefficients γ

Self Broadening + Foreign Broadening

- $$\Delta\nu = 2 c_{gas} p_{gas} \gamma_{self} + 2 \sum_{i=1}^n c_i p_i \gamma_i$$
- Consistency:** all measurements acquired within the same setup
 - Traceability:** laser tuning (etalon), pressure, temperature
 - UNIT: $10^{-3} \text{cm}^{-1}/\text{atm}$

Absorption Line	Ar	He	H2	O2	N2	CO2	Air
NO	42.68	44.06	71.66	60.39	57.60	-	-
NO (A)	37.38	37.82	62.77	58.31	50.53	-	-
CO	38.92	48.53	69.75	44.51	53.25	57.13	52.37

Conclusions

- new data provides a **base for future investigations** using laser diagnostics such as TDLAS
- Knowledge of broadening coefficients with **low uncertainty** improves simulation of spectra, that are needed to obtain absolute concentration measurements

References

- Spencer, M. N., Chackerian, C., Giver, L. P. & Brown, L. R. The Nitric Oxide Fundamental Band: Frequency and Shape Parameters for Rovibrational Lines. *Journal of Molecular Spectroscopy* vol. **165** 506–524 (1994).
- Qu, Z. & Schmidt, F. M. In situ H₂O and temperature detection close to burning biomass pellets using calibration-free wavelength modulation spectroscopy. *Appl. Phys. B Lasers Opt.* **119**, 45–53 (2015).
- Qu, Z., Steinvall, E., Ghorbani, R. & Schmidt, F. M. Tunable Diode Laser Atomic Absorption Spectroscopy for Detection of Potassium under Optically Thick Conditions. *Anal. Chem.* **88**, 3754–3760 (2016).