

Tunable diode laser absorption spectroscopy (TDLAS) for gas analysis in gasifiers

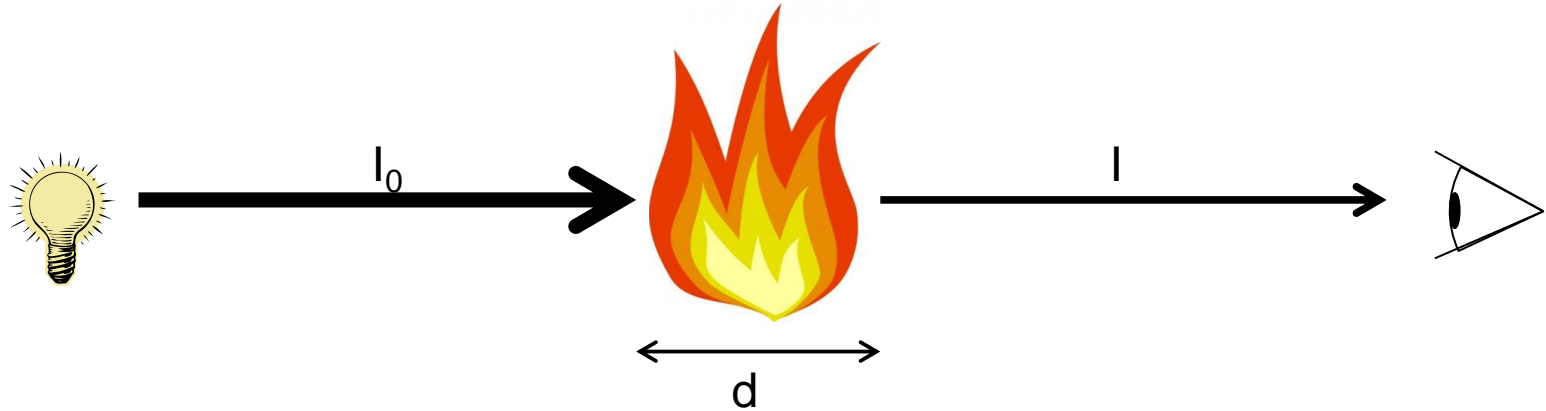
Patrick Nau, German Aerospace Center (DLR), Stuttgart



Knowledge for Tomorrow



Absorption spectroscopy



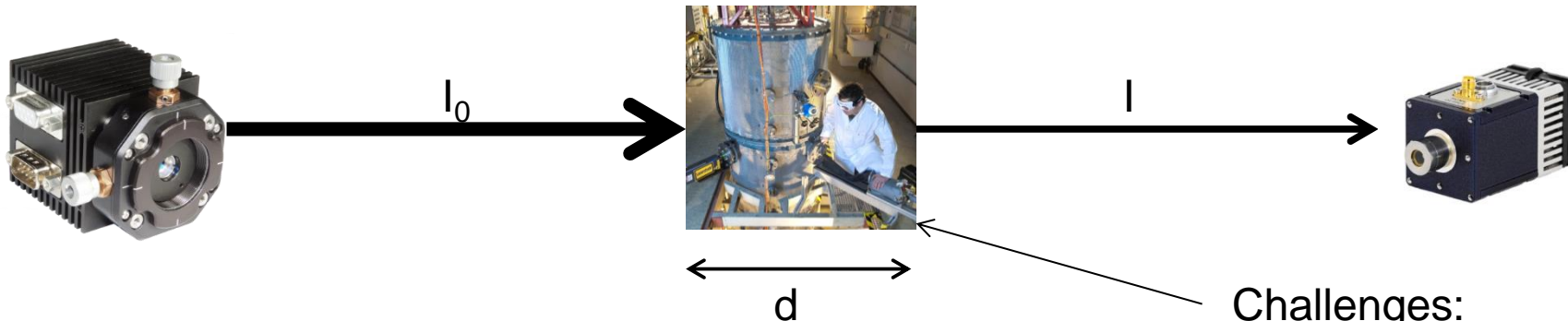
Beer-Lambert law

$$\alpha(\tilde{\nu}) = -\ln\left(\frac{I}{I_0}\right) = N \cdot d \cdot \sigma(\tilde{\nu}, T)$$

- calibration free concentration and temperature measurements
- line-of-sight technique
- Infrared absorption: detection of almost any molecule (except diatomics)



Absorption spectroscopy



Beer-Lambert law

$$\alpha(\tilde{\nu}) = -\ln\left(\frac{I}{I_0}\right) = N \cdot d \cdot \sigma(\tilde{\nu}, T)$$

Challenges:

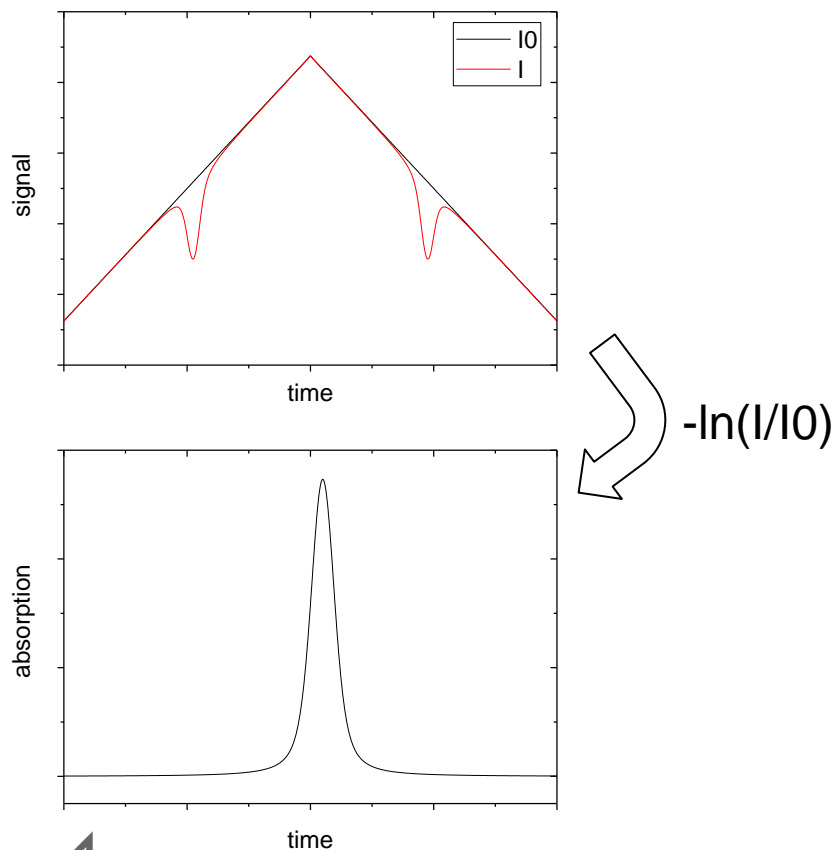
- High temperature
- High pressure
- High particle load

- calibration free concentration and temperature measurements
- line-of-sight technique
- Infrared absorption: detection of almost any molecule (except diatomics)

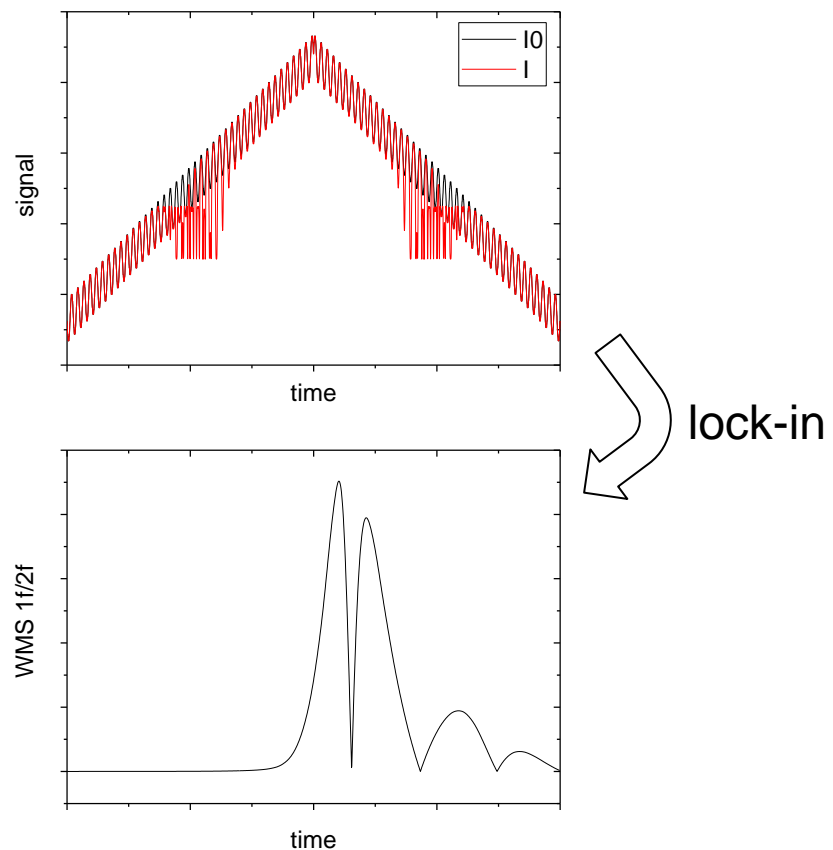


Measurement principle

- Direct absorption (LDAS)

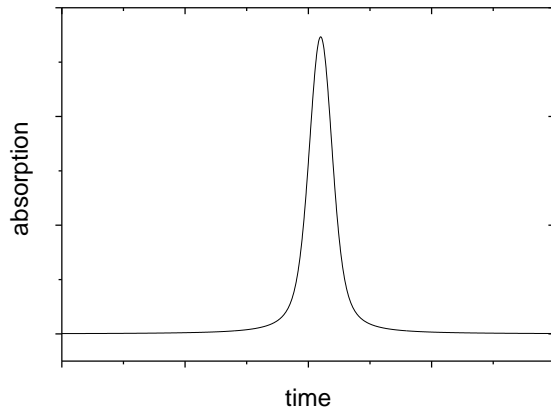


- Wavelength modulation spectroscopy (WMS)



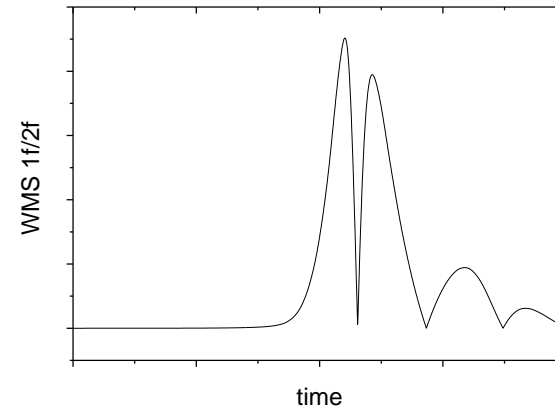
Measurement principle

- Direct absorption (LDAS)



- Relatively simple implementation and data evaluation
- Calibration free

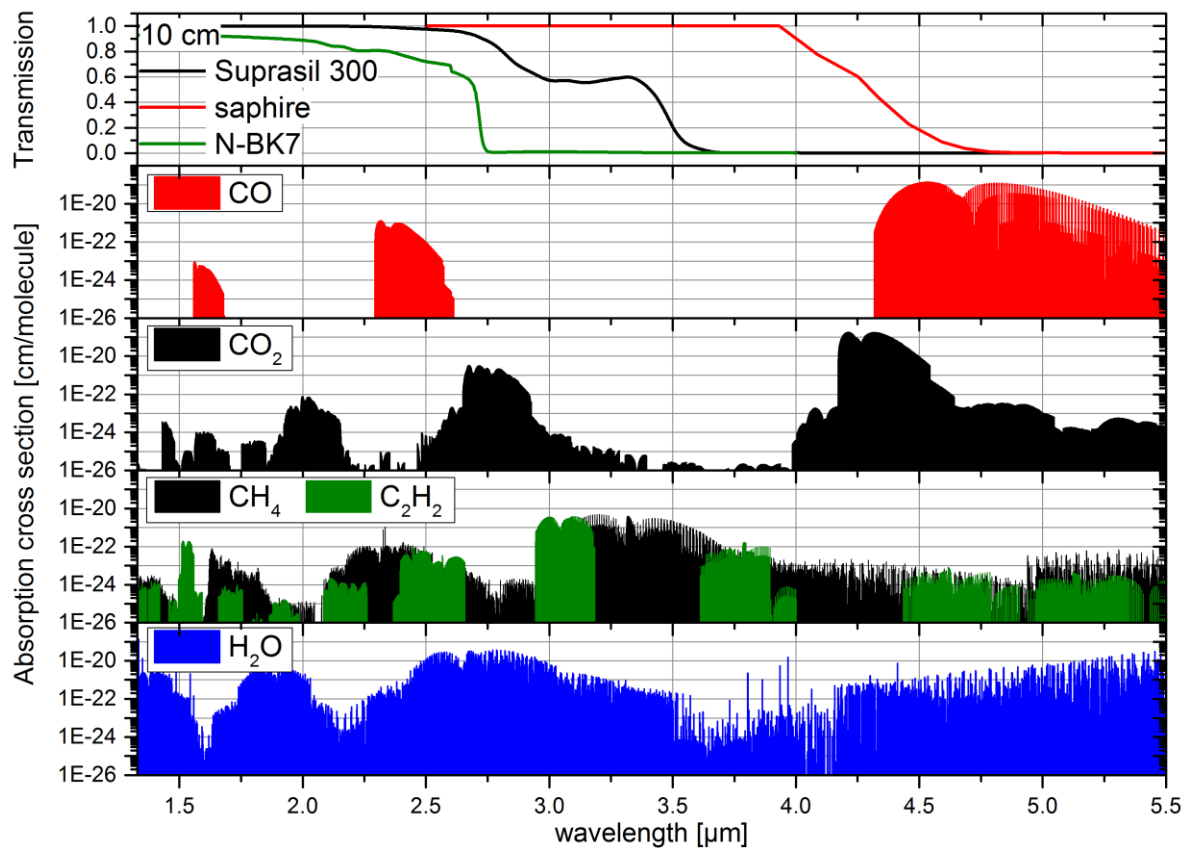
- Wavelength modulation spectroscopy (WMS)



- Better sensitivity and selectivity
- More complicated quantification

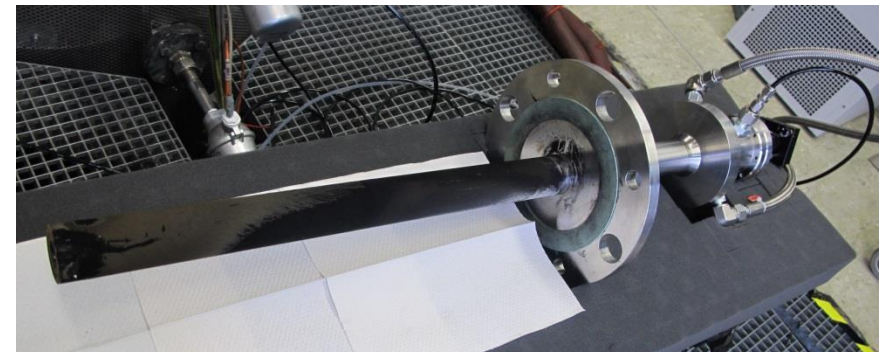
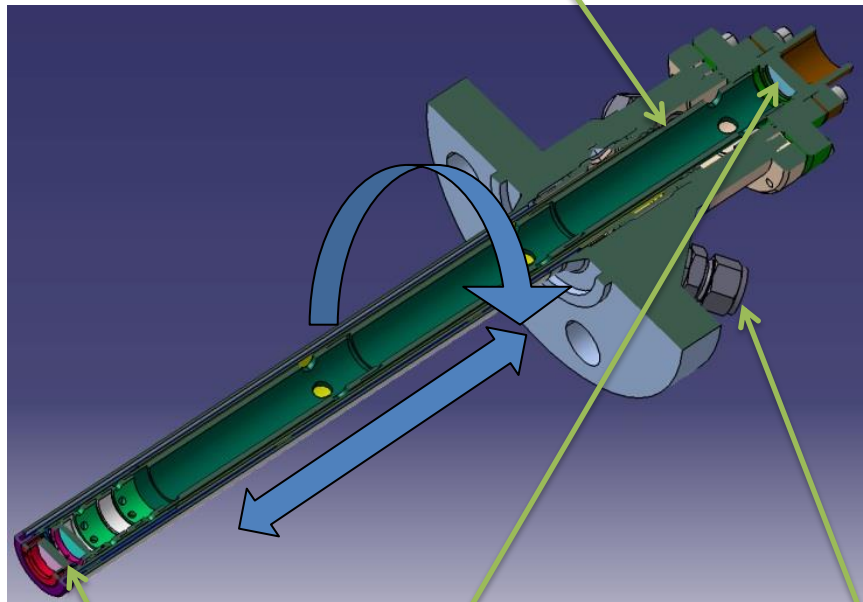


Infrared absorption spectra



Optical access

nitrogen purge

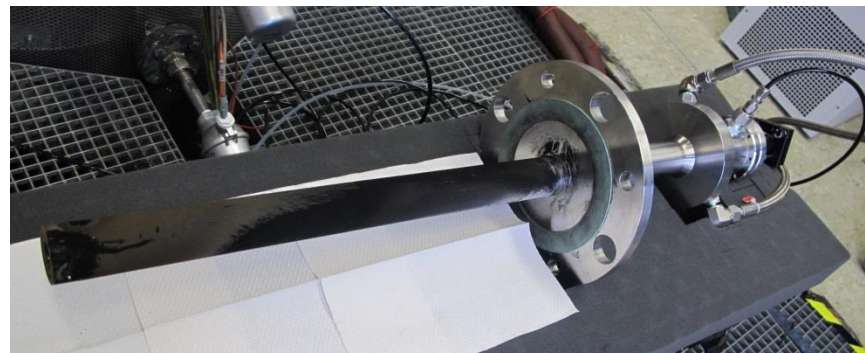
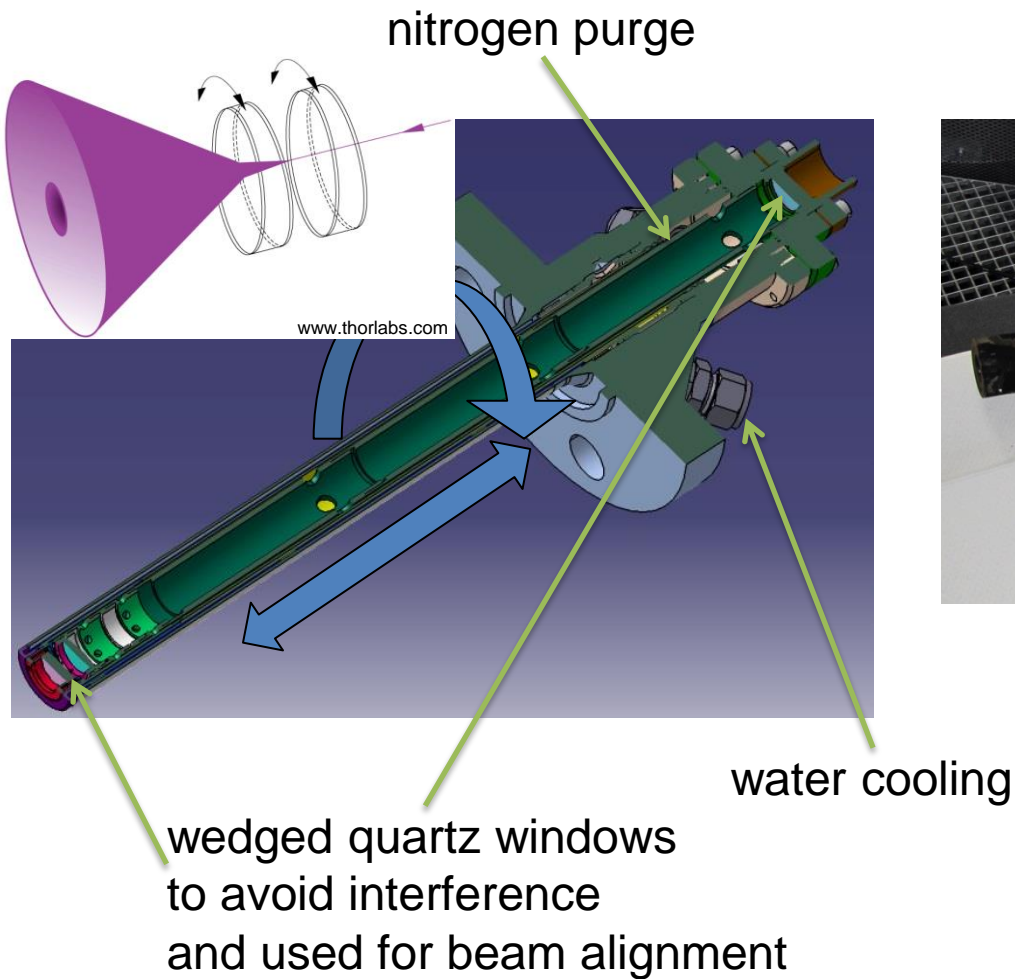


water cooling

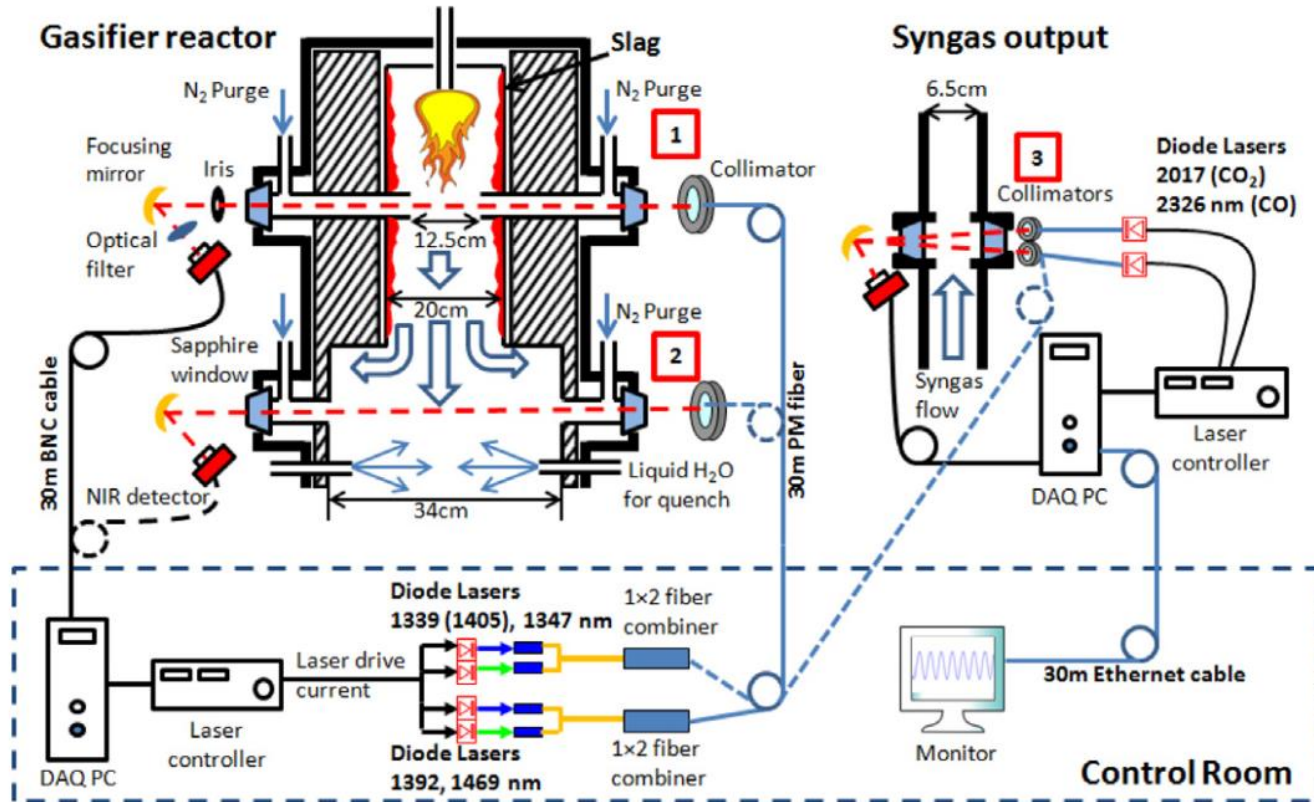
wedged quartz windows
to avoid interference



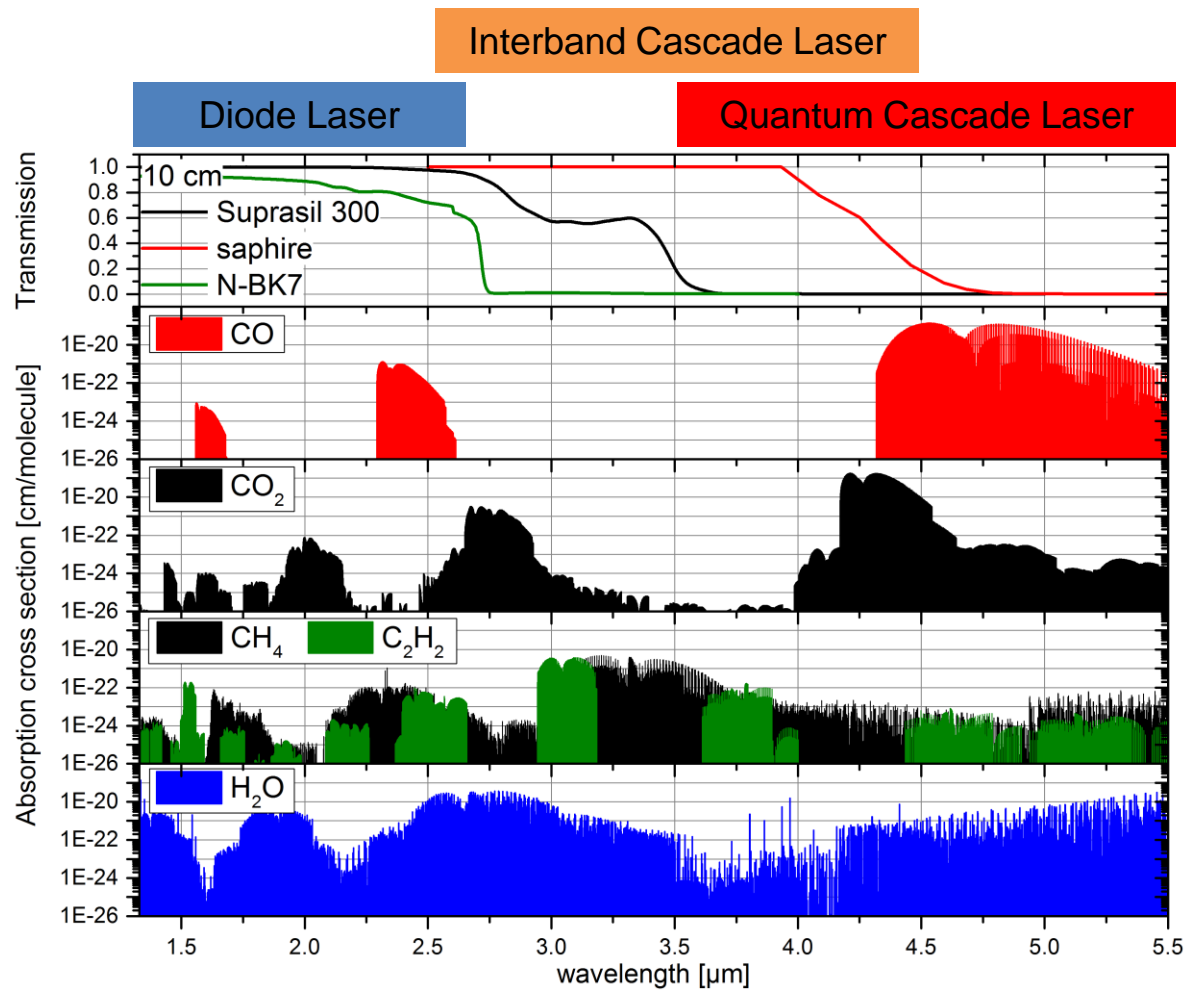
Optical access



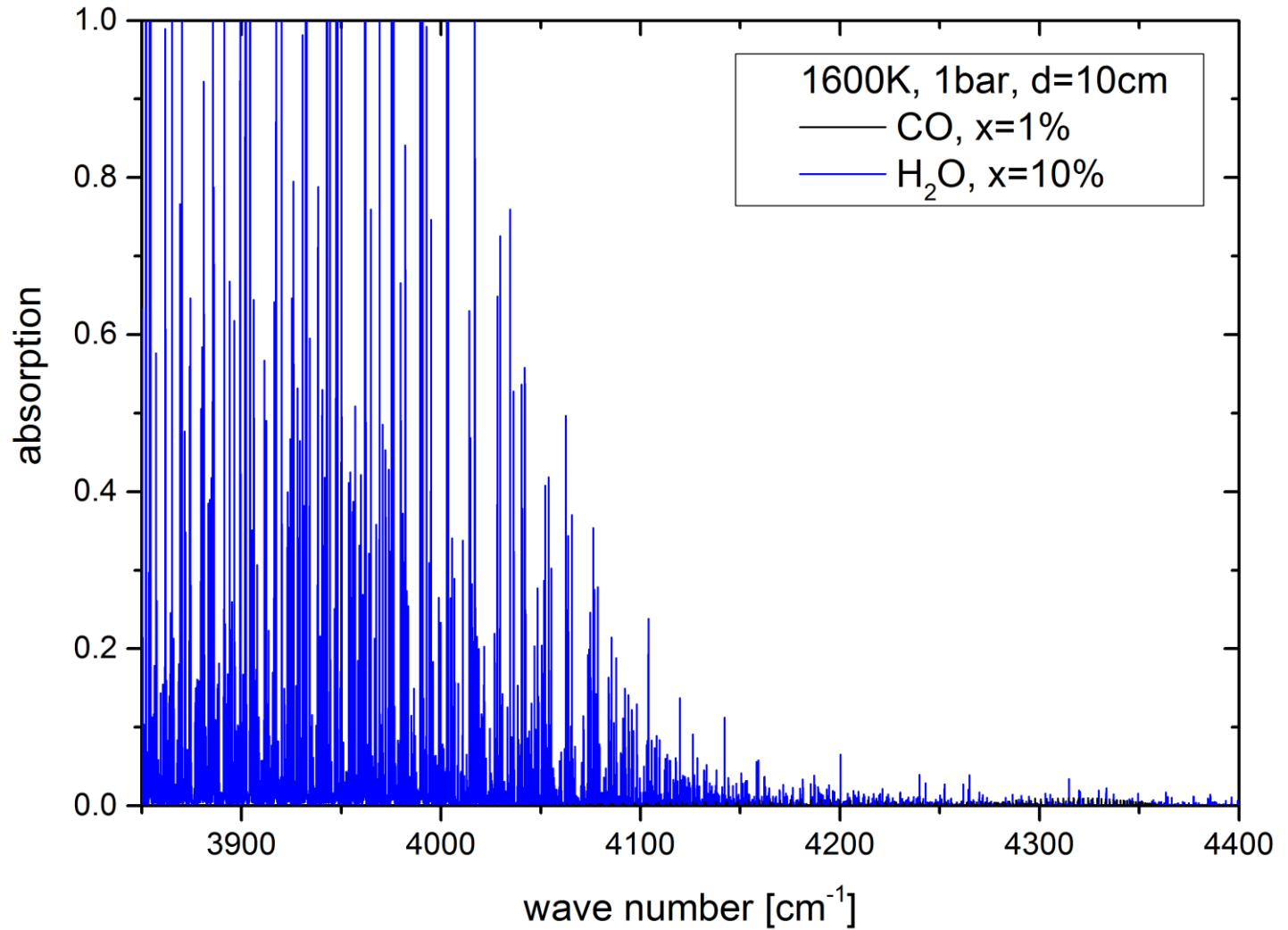
Optical access



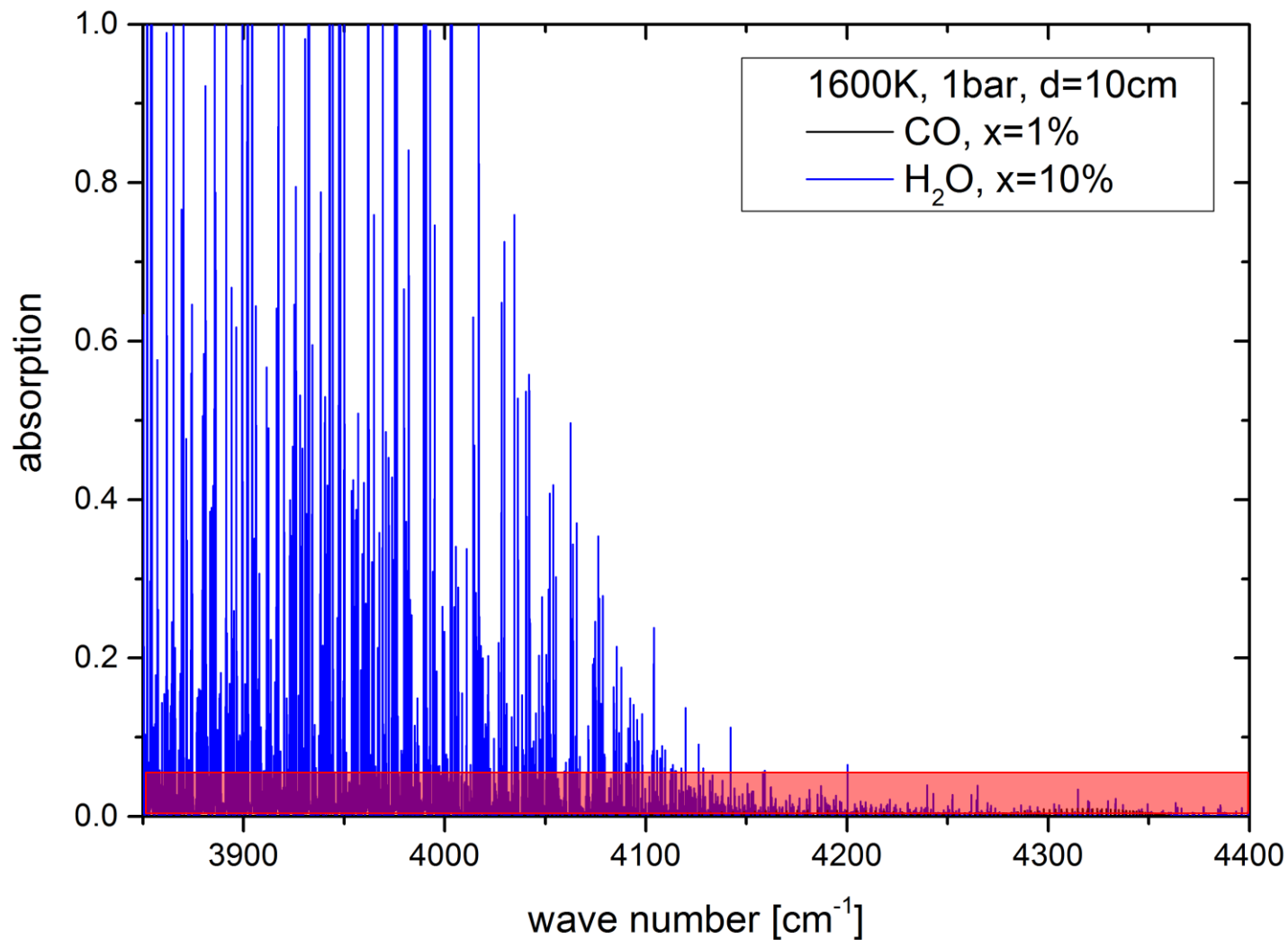
Line selection



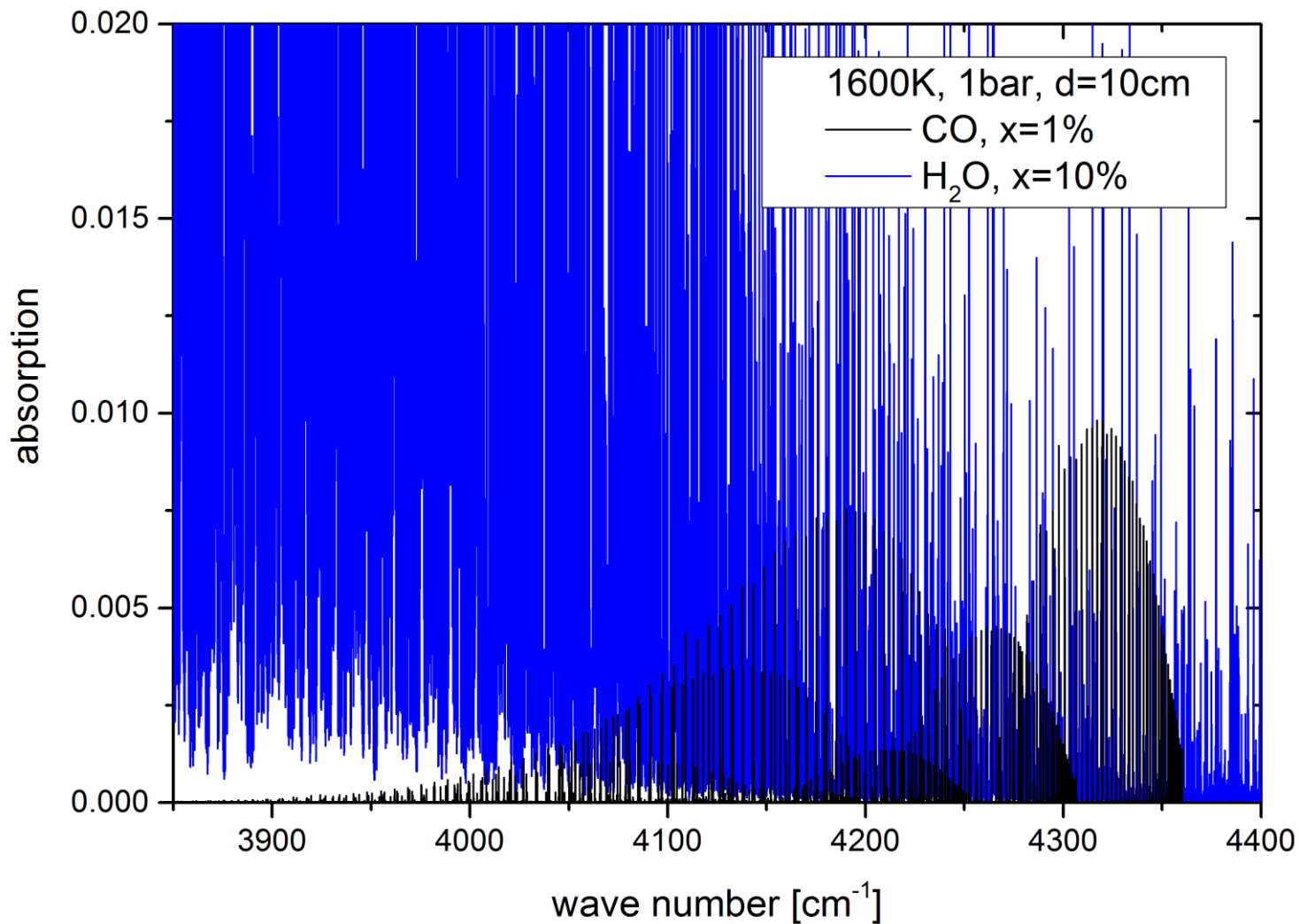
Line selection



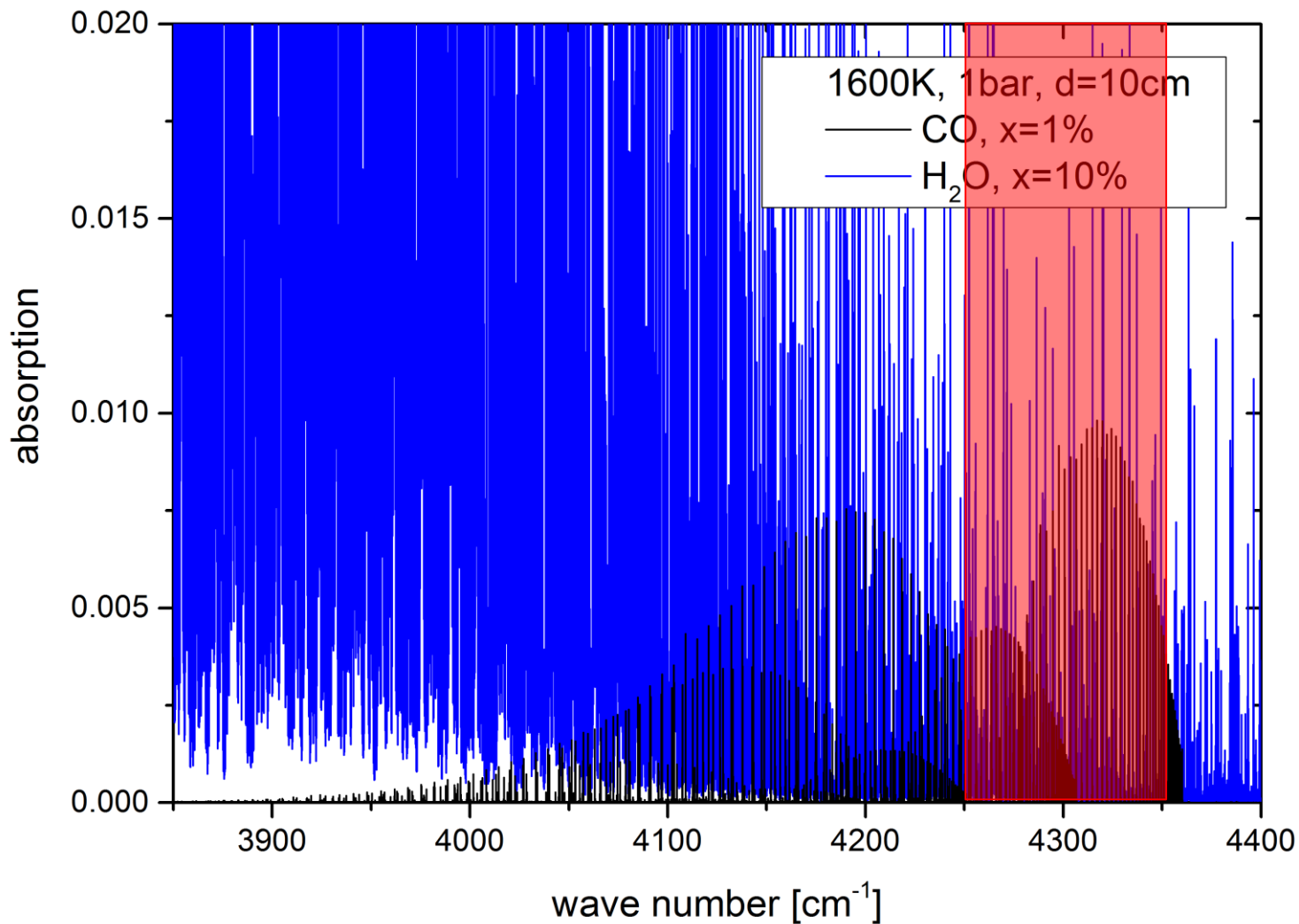
Line selection



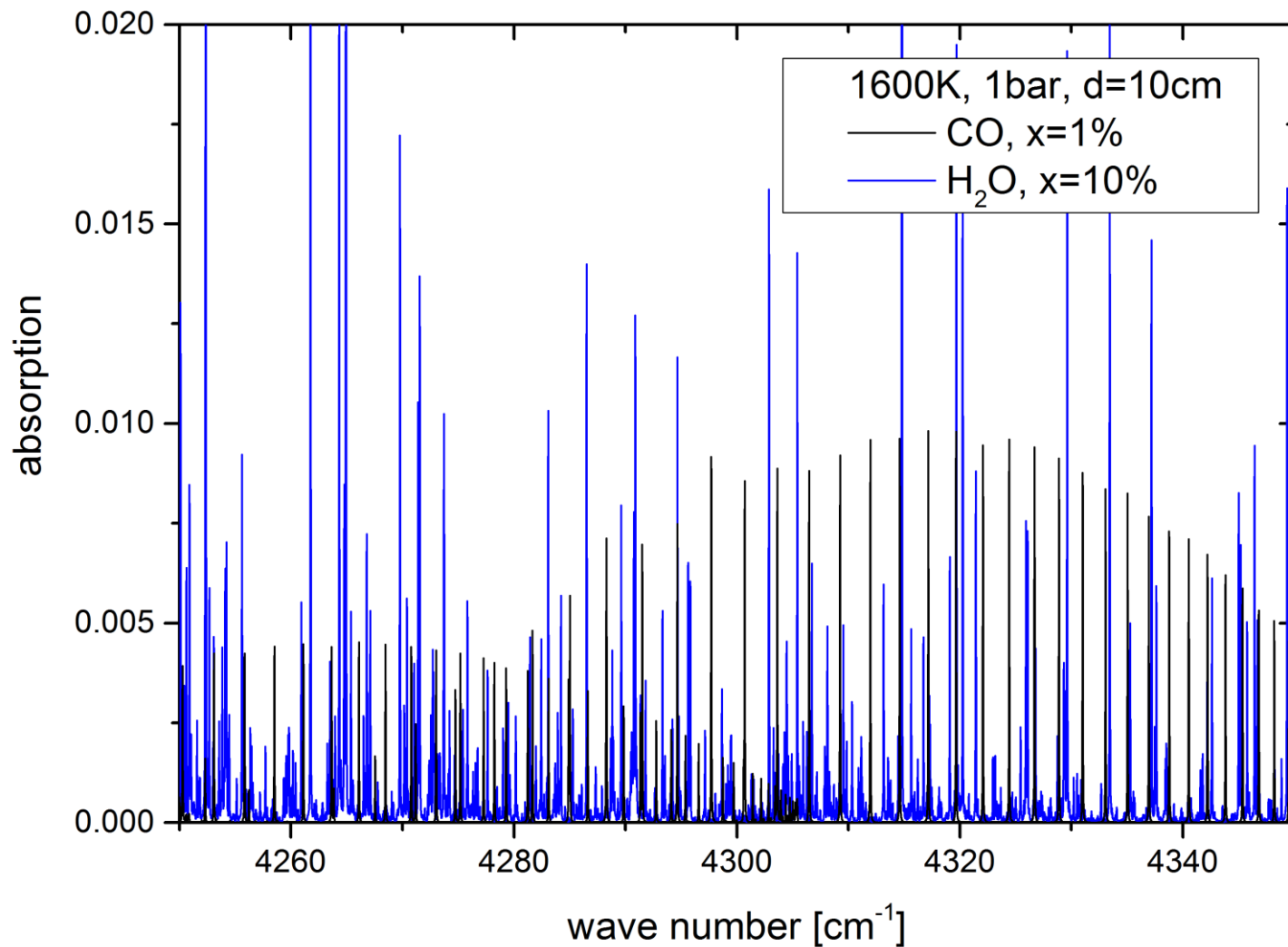
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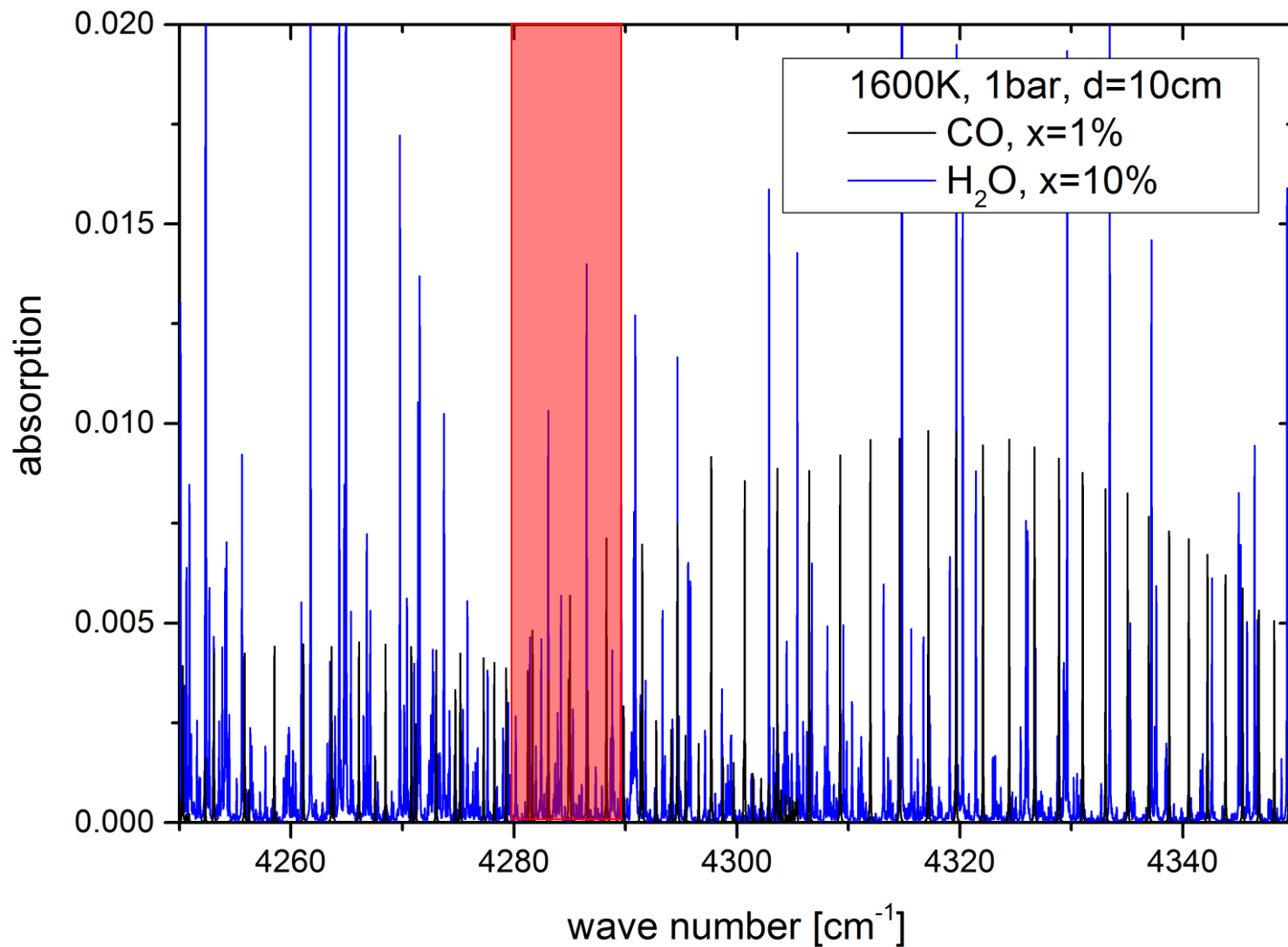
Line selection



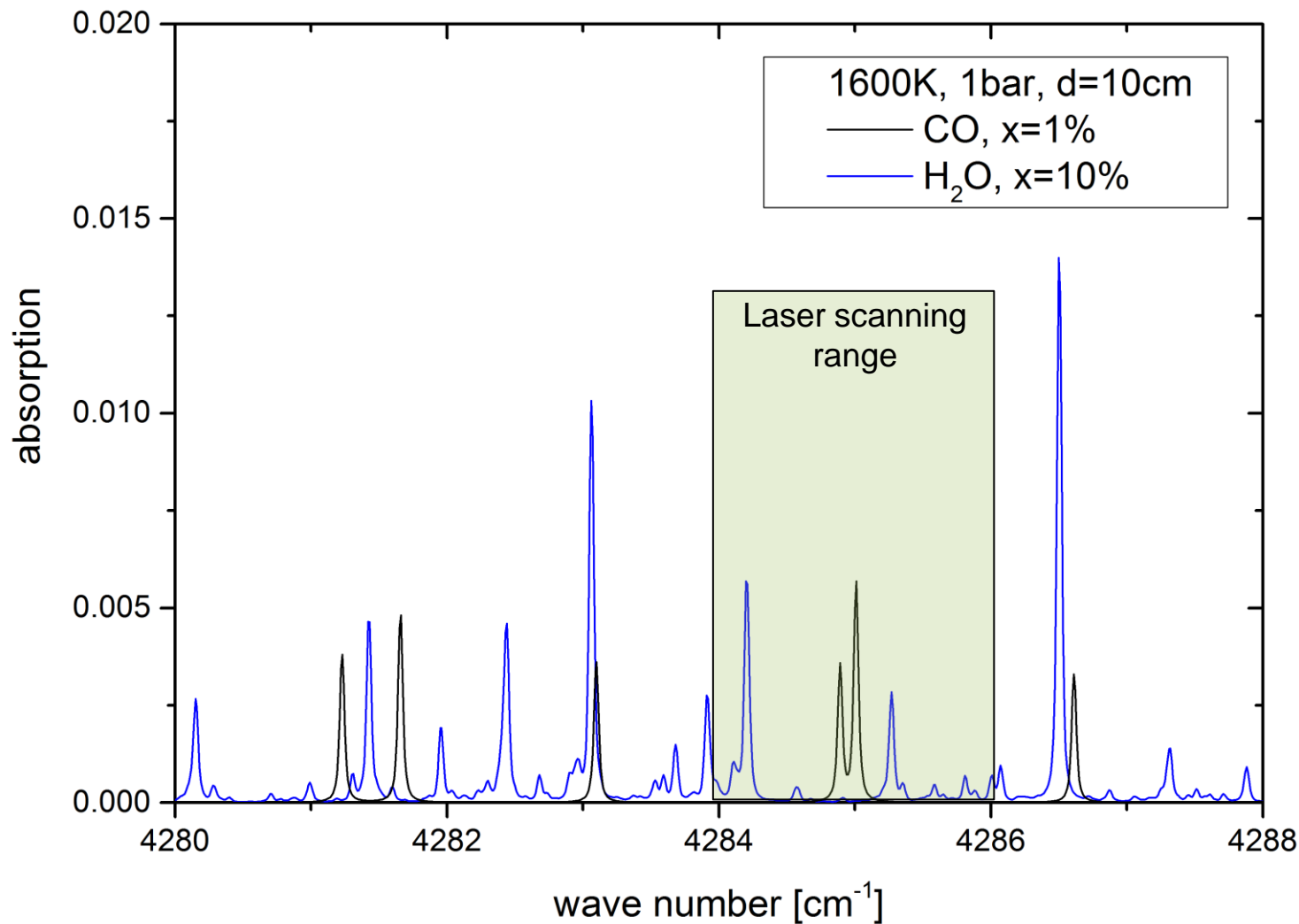
Line selection



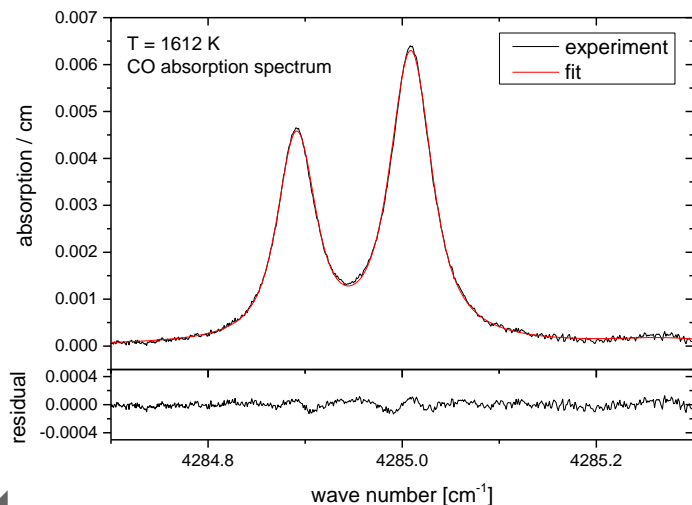
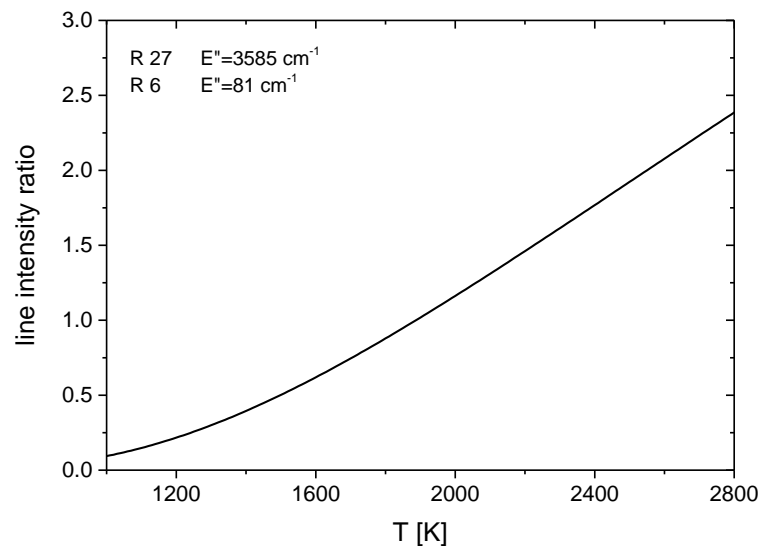
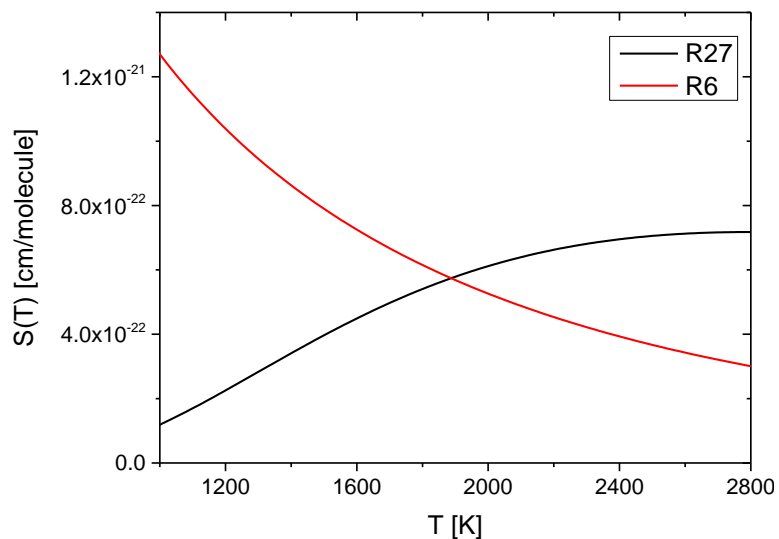
Line selection



Line selection



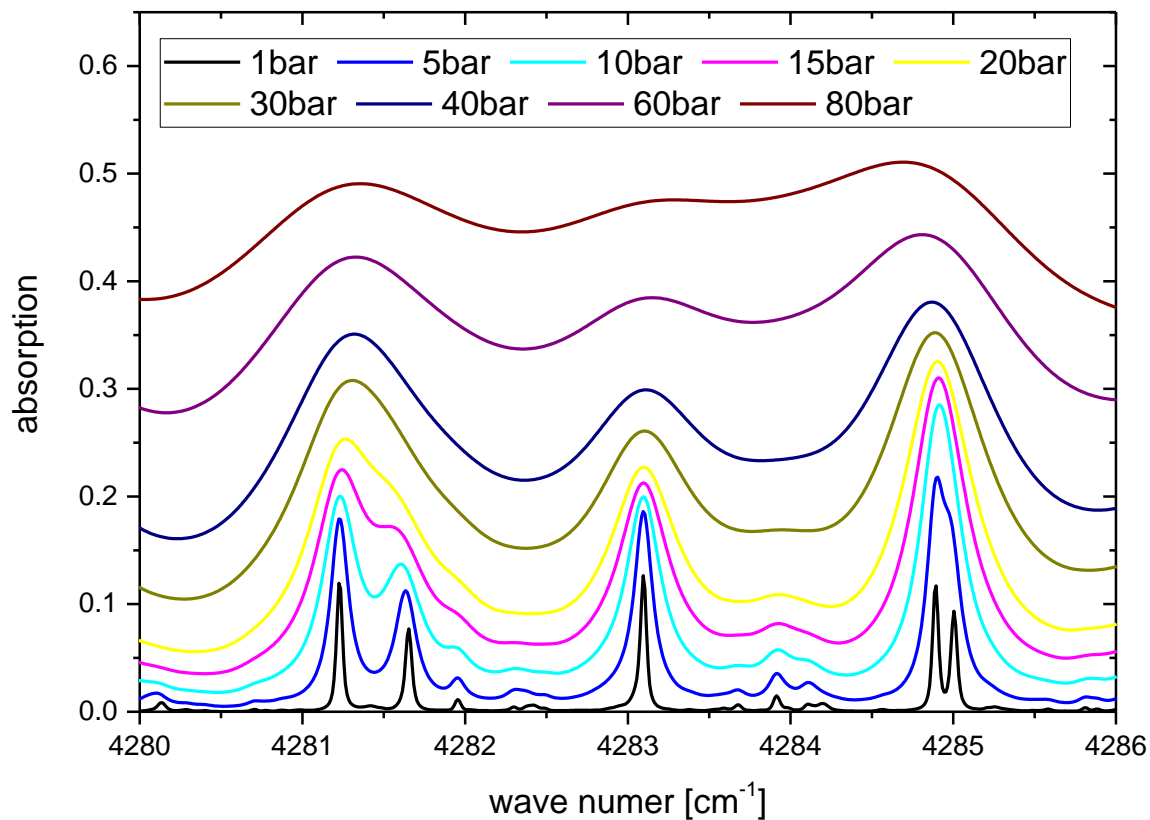
Temperature sensitivity of CO line pair



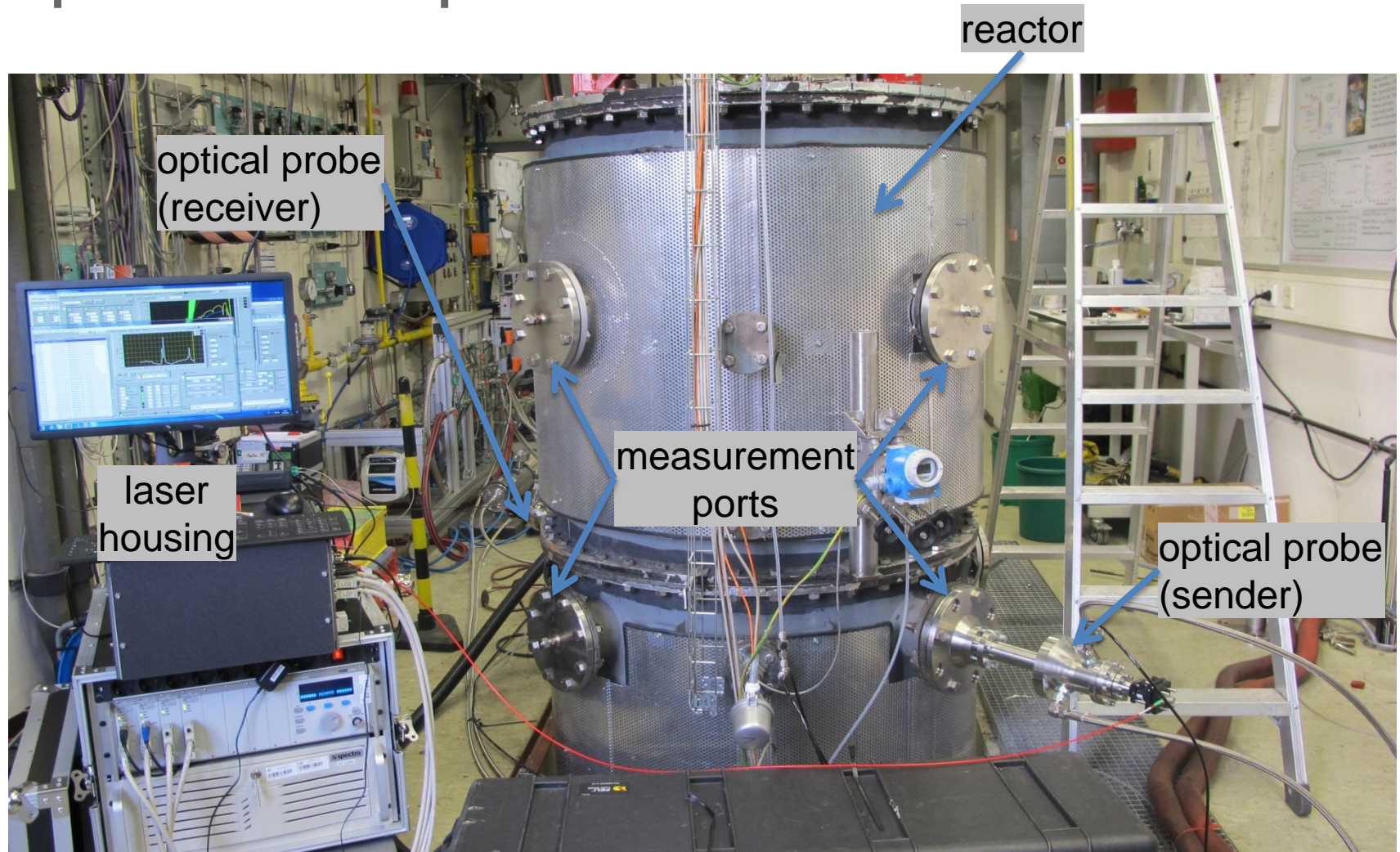
- T from intensity ratio
- Mole fraction from line area



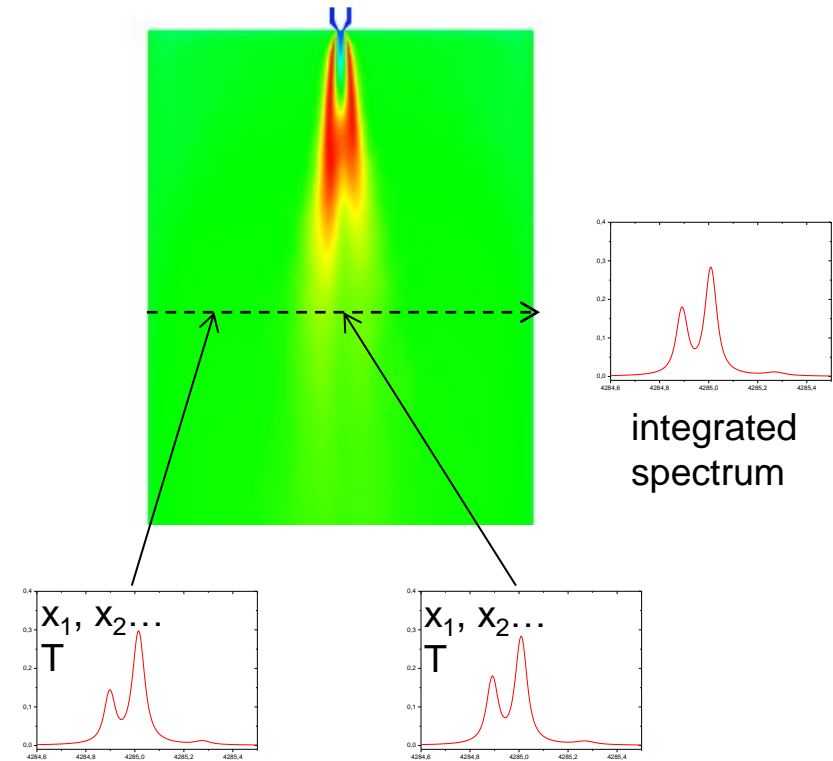
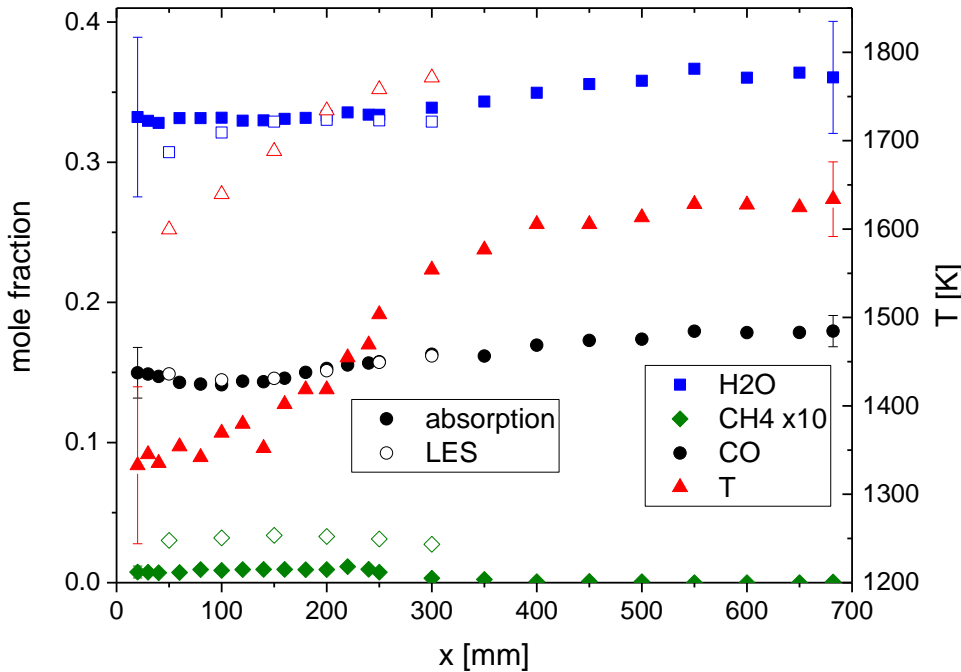
Pressure broadening



Experimental setup at REGA



Comparison with numerical simulations



How to compare line-of-sight data (1D) with numerical simulations (2D)?



Calculate absorption spectra based on data from LES simulation

LES simulation: G. Eckel et.al., 8th International Freiberg Conference, 2016



Conclusion

- Laser absorption enables temperature and species mole fraction measurements
 - Direct absorption: straightforward and calibration free
 - WMS: higher sensitivity but more complicated data evaluation
- Careful line selection necessary
- Robust optical fiber setup
- Application at high pressure limited by pressure broadening of absorption lines and scanning range of diode laser



Thank you



Knowledge for Tomorrow

