

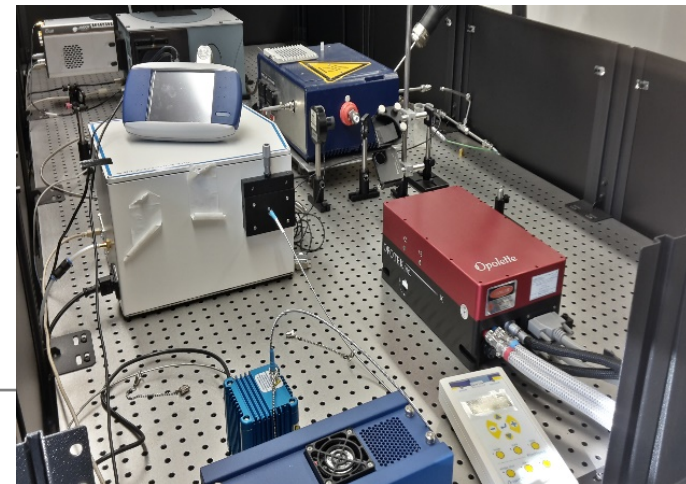
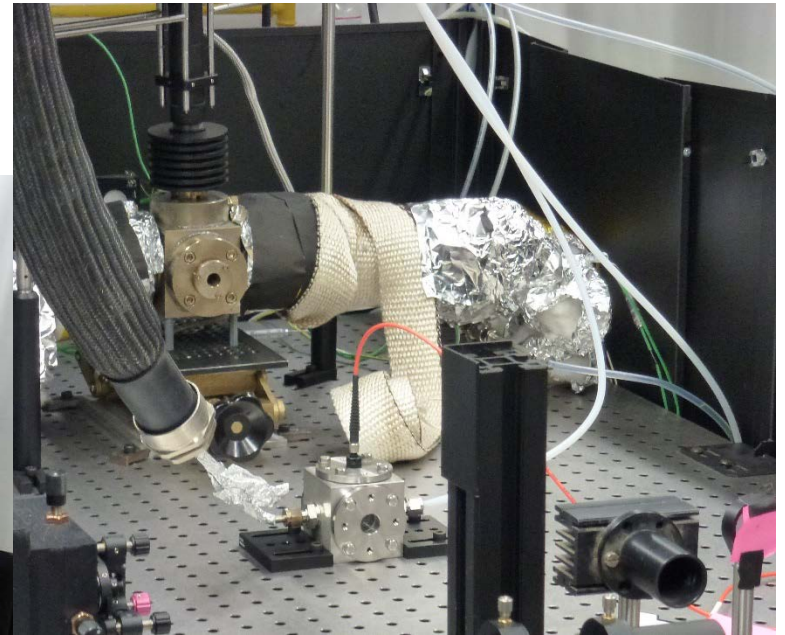
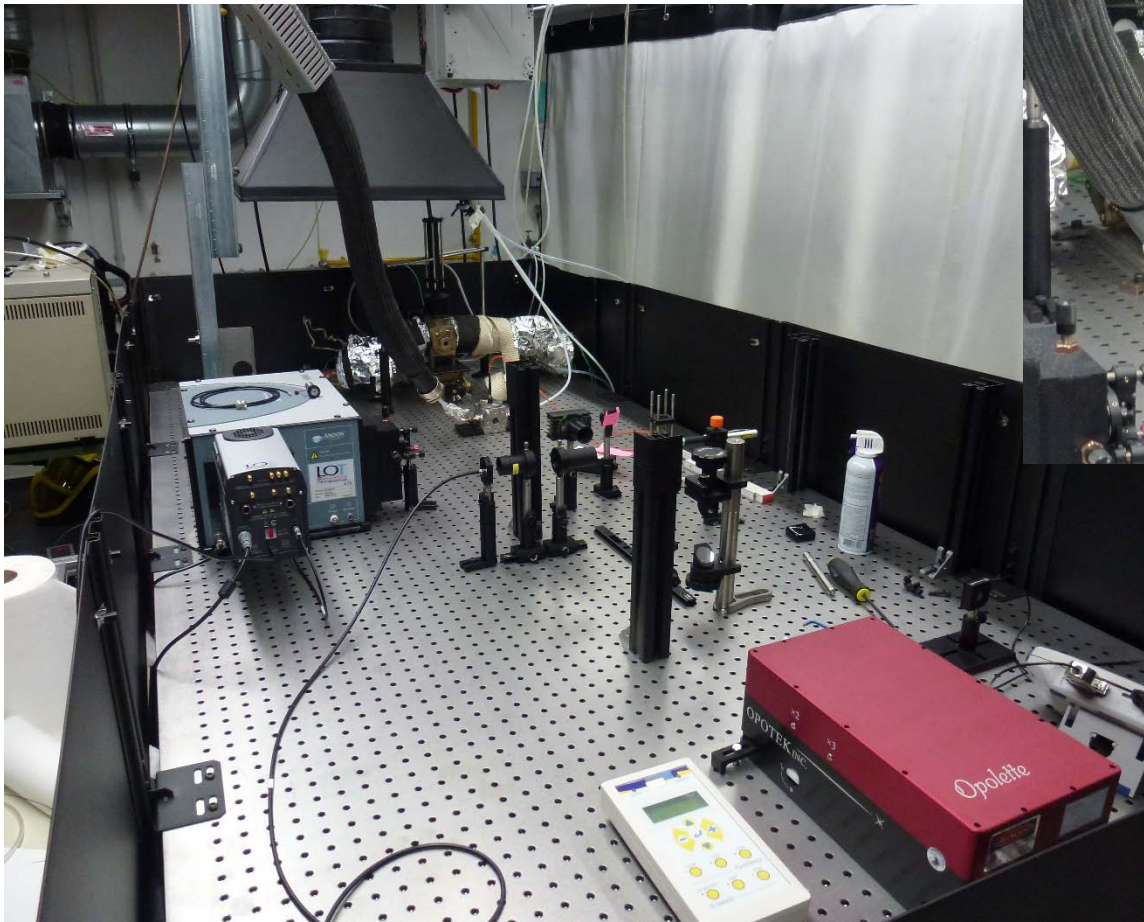


Online monitoring of aromatics using light-induced fluorescence

York Neubauer, Julian Borgmeyer

Institute of Energy Engineering | TCKON & BioProGReSs | GAW2016 Amsterdam 10.06.2016

Fluorescence PAC-analysis with tunable light sources



Online monitoring and analysis of tar forming species using tunable light sources

- **Fundamental research**
 - Excitation emission matrices
 - Gaining information from complex spectra of mixtures
- **Sensor development for on-line monitoring and for process control**

Fundamental research – Excitation-Emission-Matrices (EEM's)

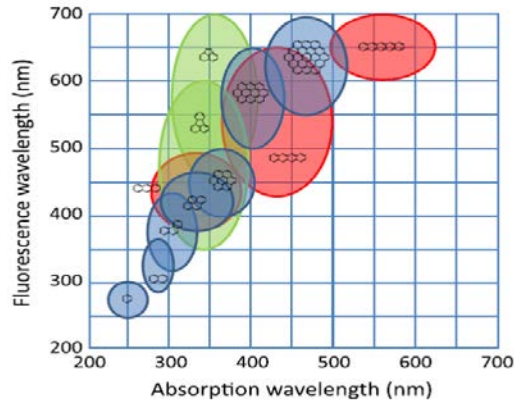
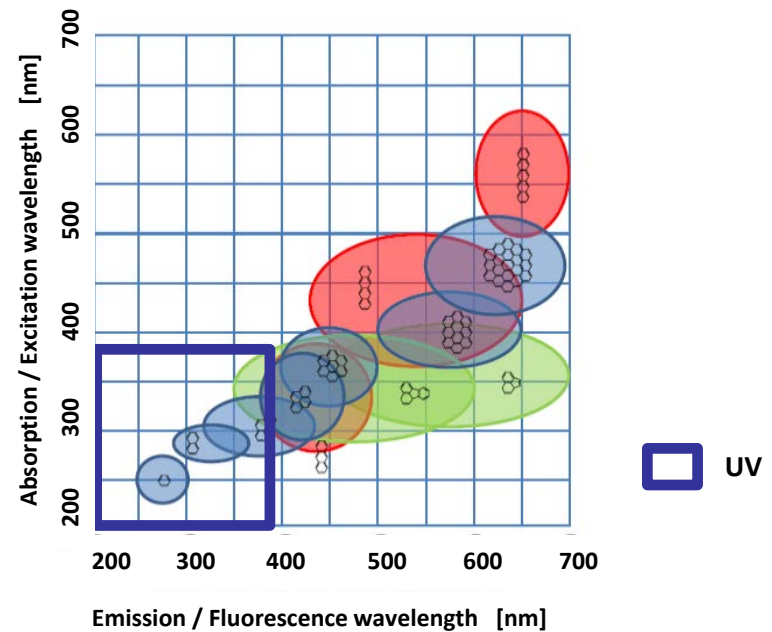


Fig. 6a. Lowest energetic absorption spectral range and fluorescence emission of several PAHs potentially formed in flames at ambient temperature.

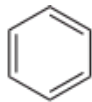


Taken and Adapted from:

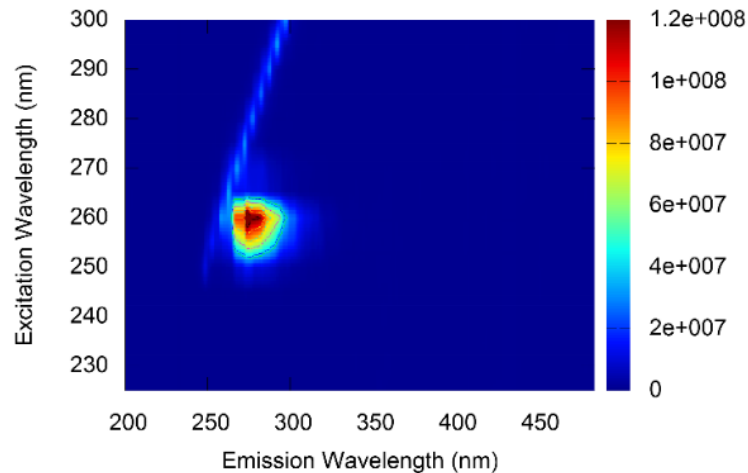
S. Bejaoui, X. Mercier, P. Desgroux, E. Therssen: Laser induced fluorescence spectroscopy of aromatic species produced in atmospheric sooting flames using UV and visible excitation wavelengths. *Combustion and Flame* 161 (2014) 2479–2491

Fundamental research – Excitation-Emission-Matrices (EEM's)

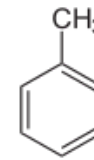
Benzene (150°C)



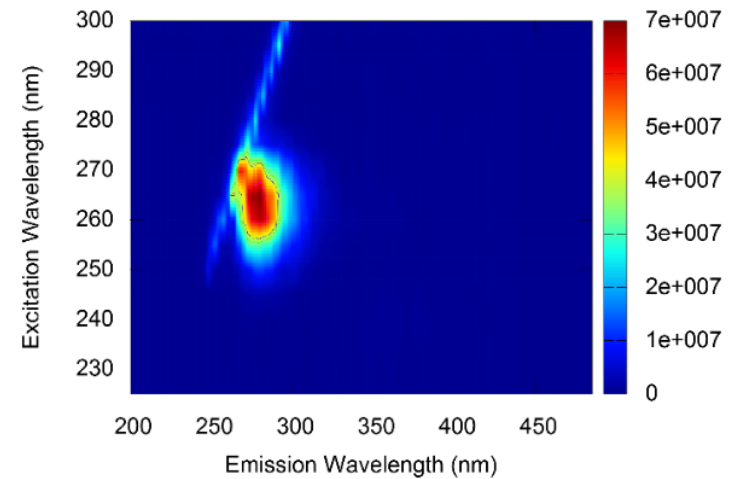
Benzol 20µl/min 150°C Int. 1s



Toluene (150°C)

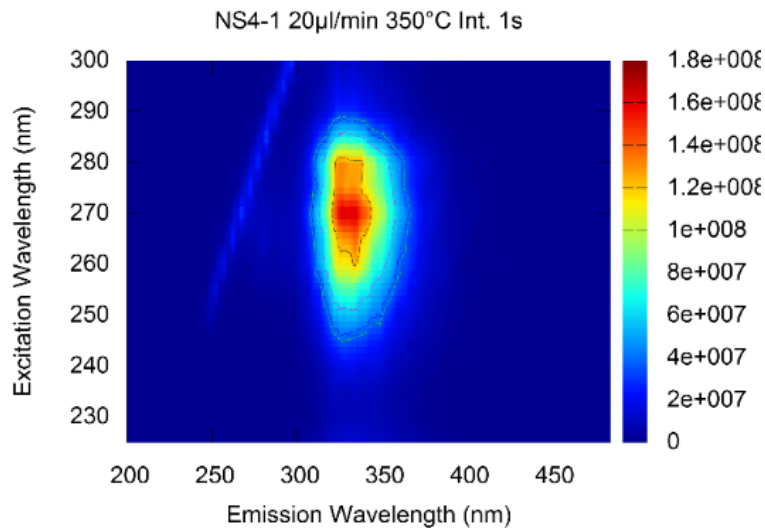
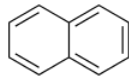


Toluol 20µl/min 150°C Int. 1s

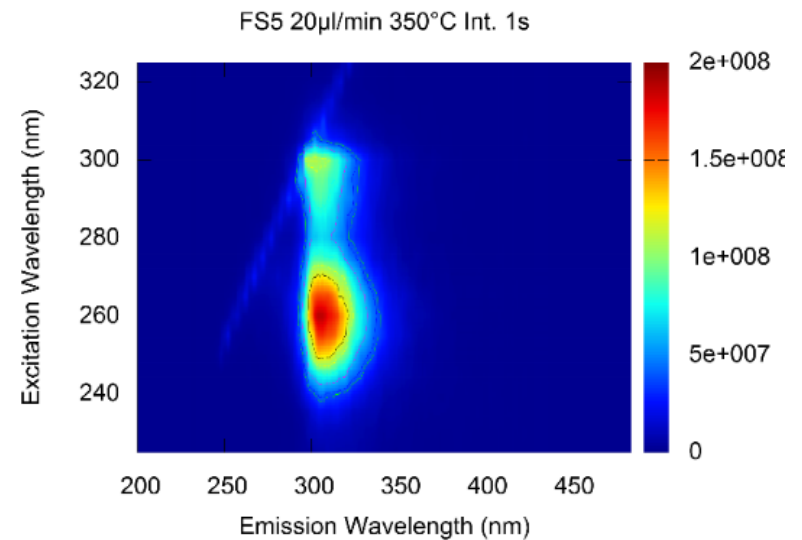
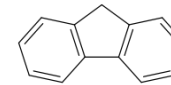


Fundamental research – Excitation-Emission-Matrices

Naphthalene

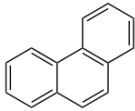


Fluorene

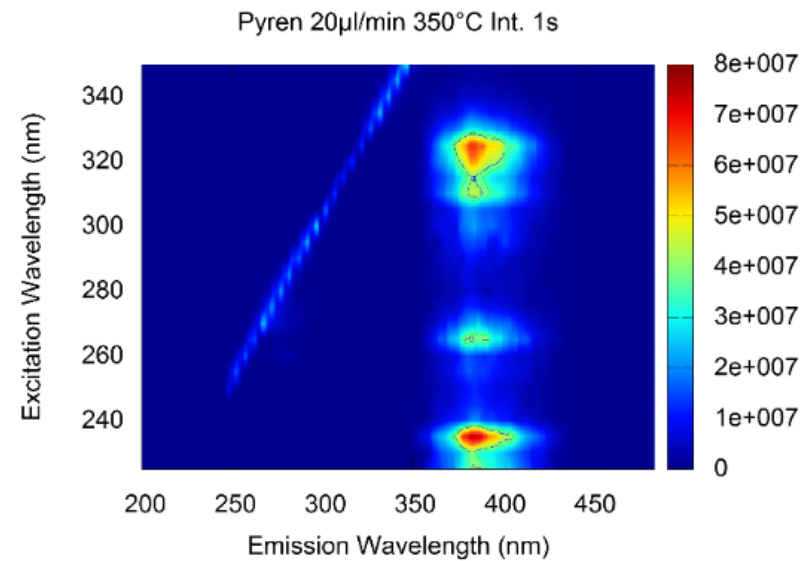
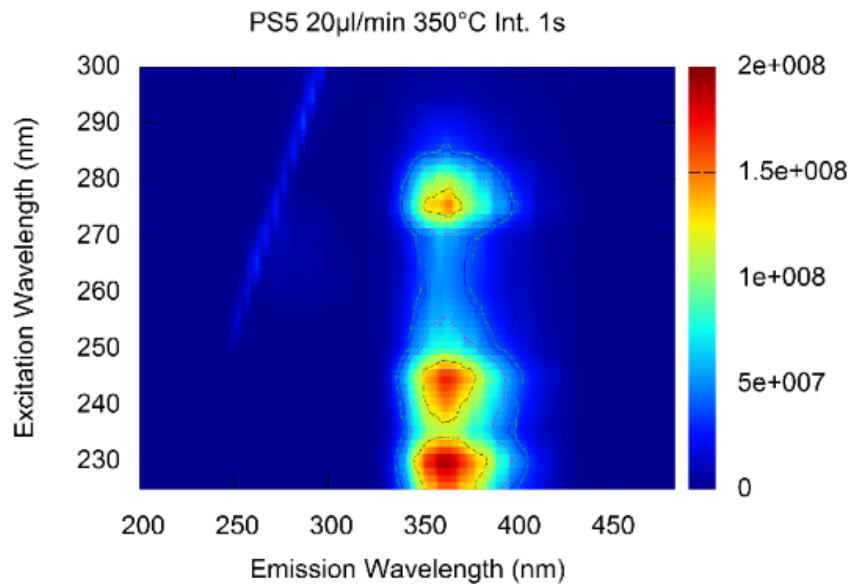
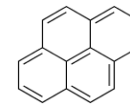


Fundamental research – Excitation-Emission-Matrices

Phenanthrene



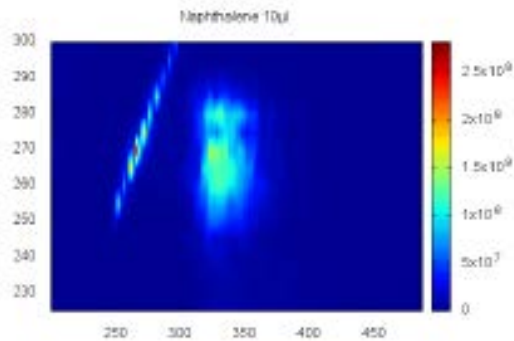
Pyrene



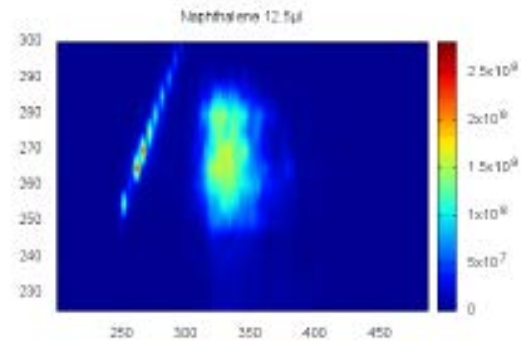
Fundamental research – Excitation-Emission-Matrices

Abbildung 2.2: Naphthalene EEM colormaps at different concentrations c_i .

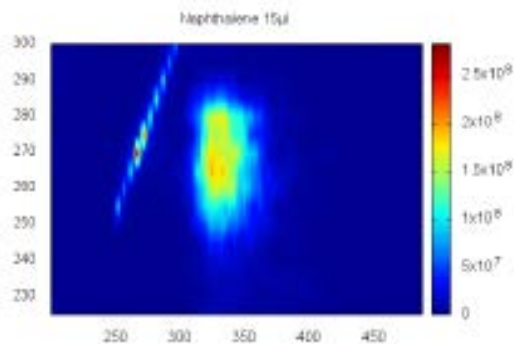
(a) $c_1 = 1500 \text{ mg/Nm}^3$



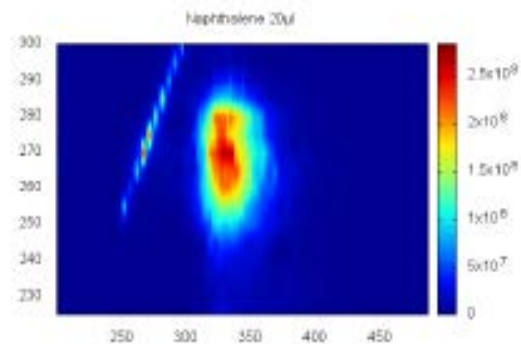
(b) $c_2 = 1875 \text{ mg/Nm}^3$



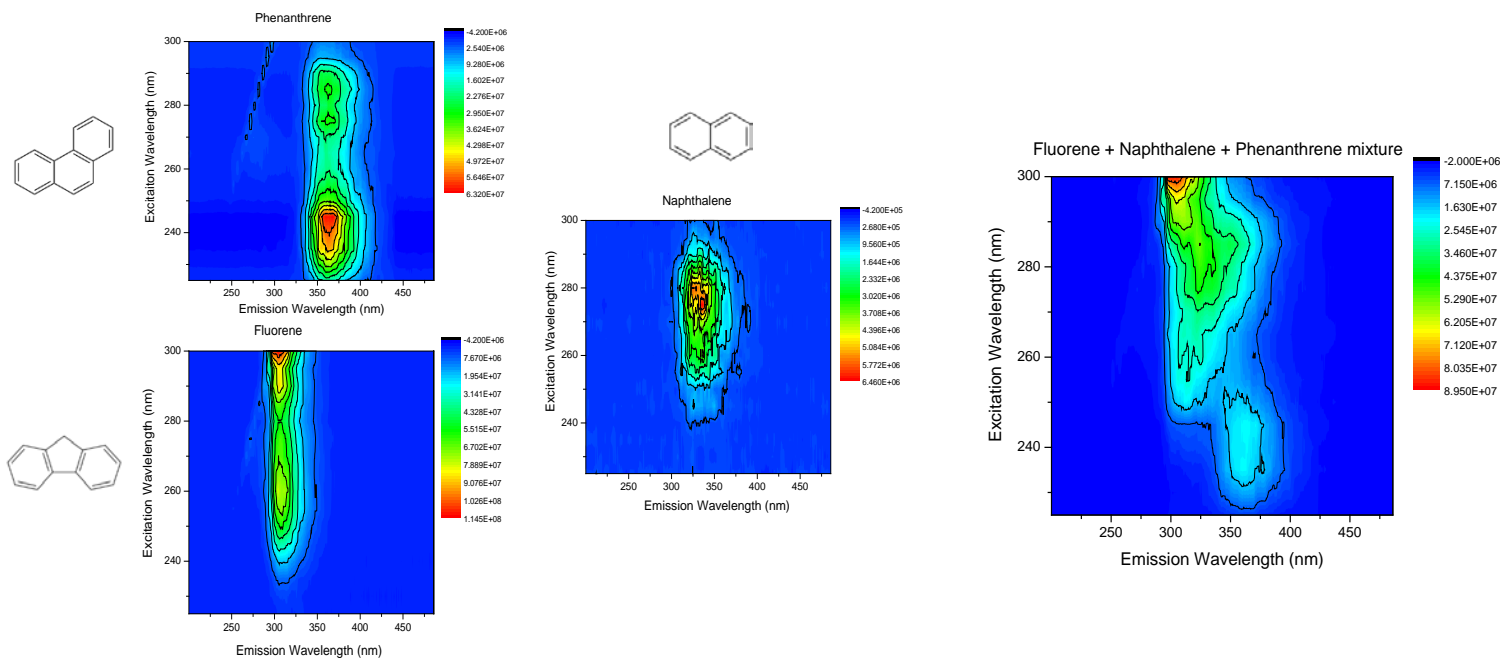
(c) $c_3 = 2250 \text{ mg/Nm}^3$



(d) $c_4 = 3000 \text{ mg/Nm}^3$

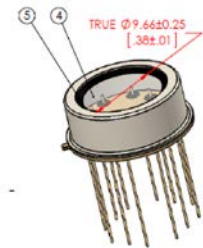
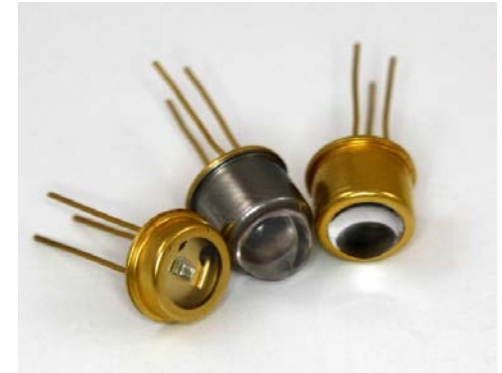


Fundamental research – Excitation-Emission-Matrices (EEM's)

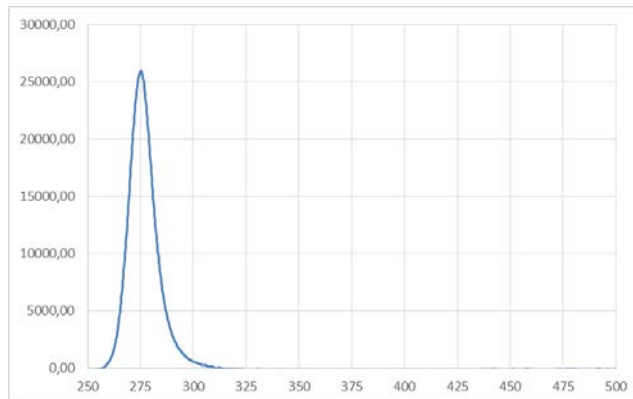


Light source - options

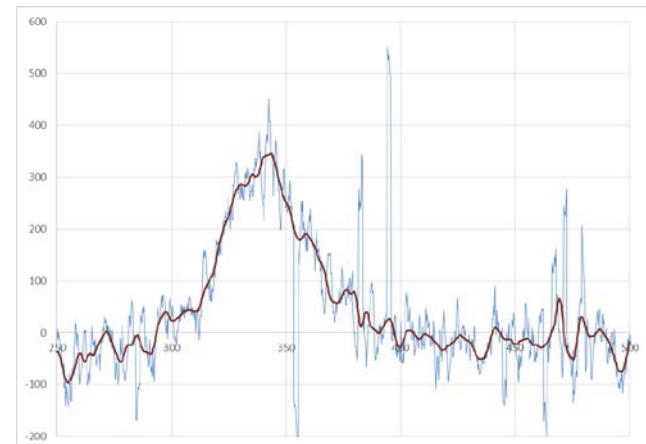
- Conventional: Laser
 - Stability and reliability in rough environments necessary
 - Only one wavelength (no EEM)
 - Expensive
- New Approach: LEDs and LED Matrices
 - Not sensitive to vibration, temperature control is necessary
 - Much lower cost compared with lasers
 - Multi-wavelength is possible (multiple emitters in one housing)



LED Emission (=Excitation) spectrum



Fluorescence Spectrum - naphthalene

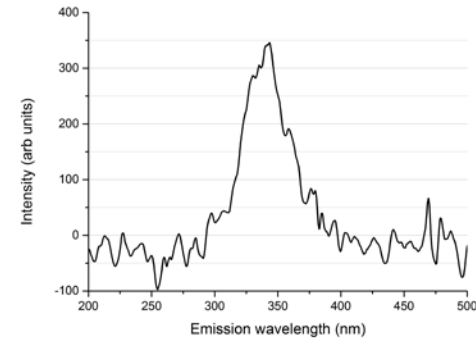
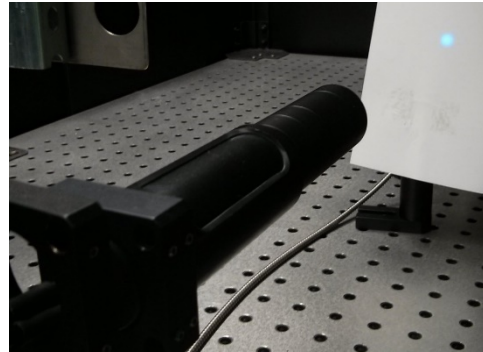
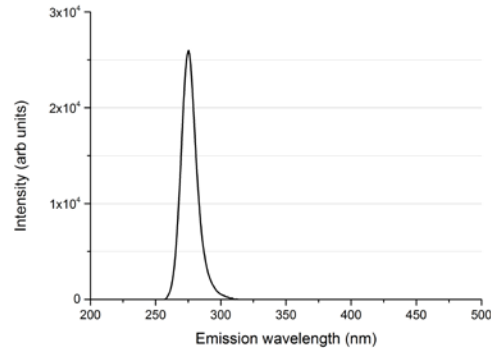


Tar Sensor - Requirements

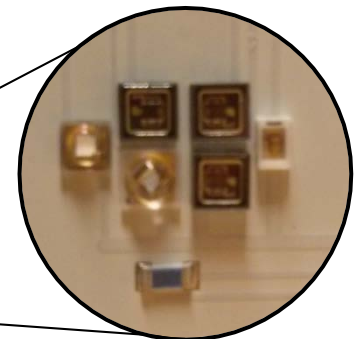
- Window purging
- Controllable gas flow
- Complete oxidation of the producer gas after the measurement
- Elimination of cold junctions where tar condenses
- Stable, robust light source
- Active cooling of the light source and the spectrometer

Tar Sensor - Light Source

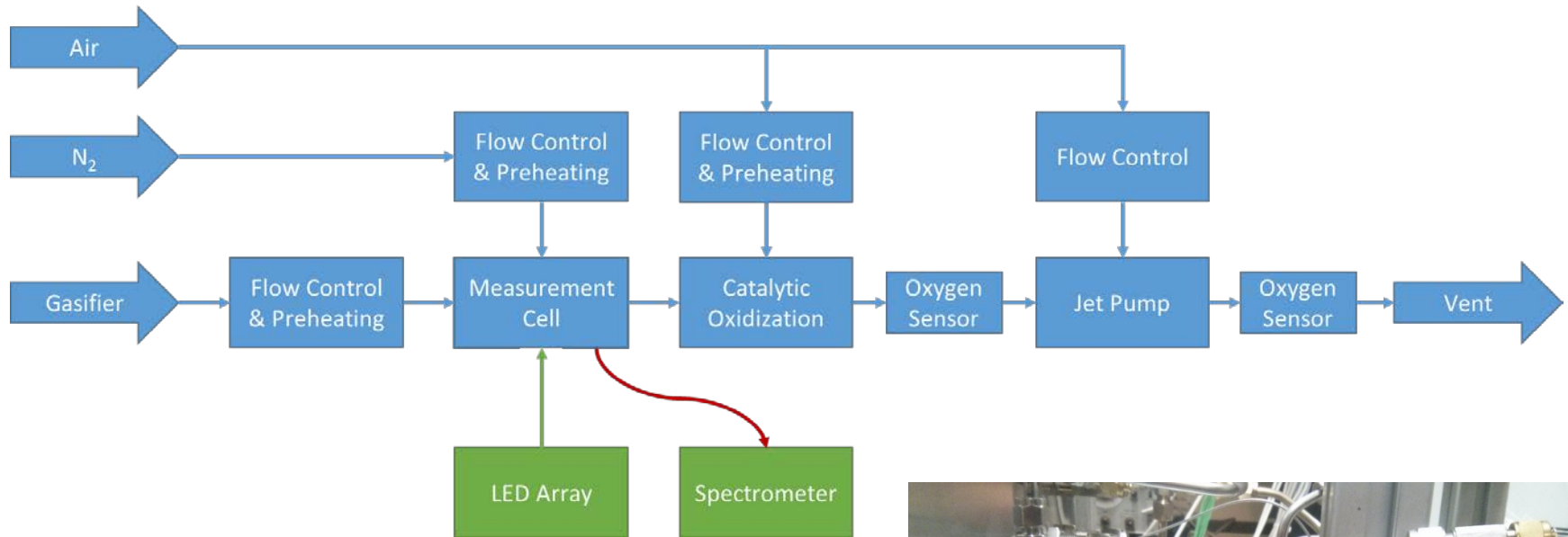
- Diodes instead of lasers for excitation



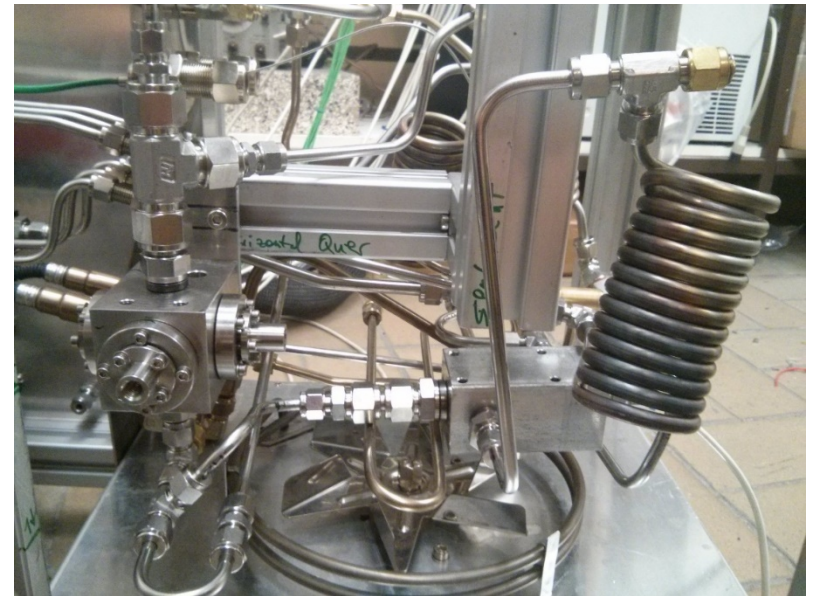
- Diode array with different wavelengths
 - 265, 280, 300, 340, 380, 455 nm



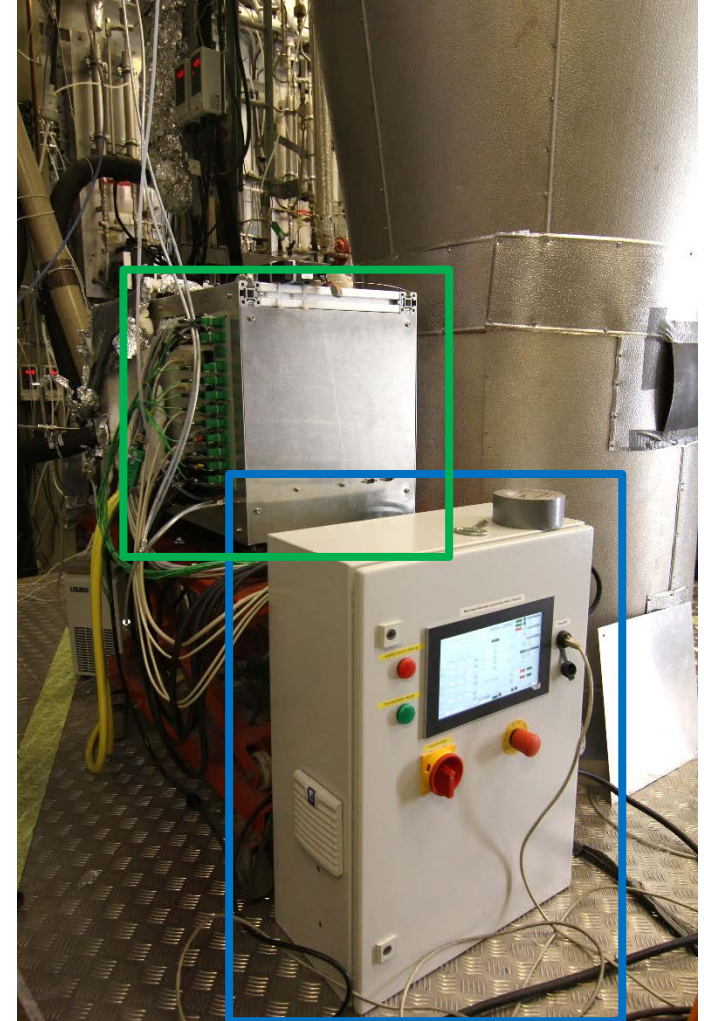
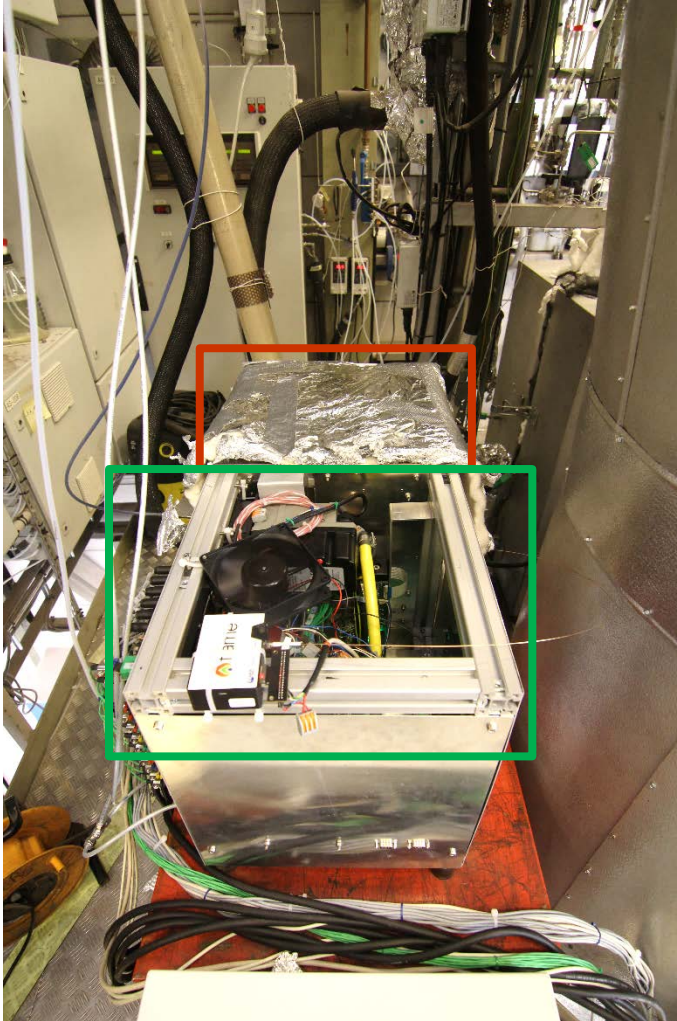
Tar Sensor - Setup



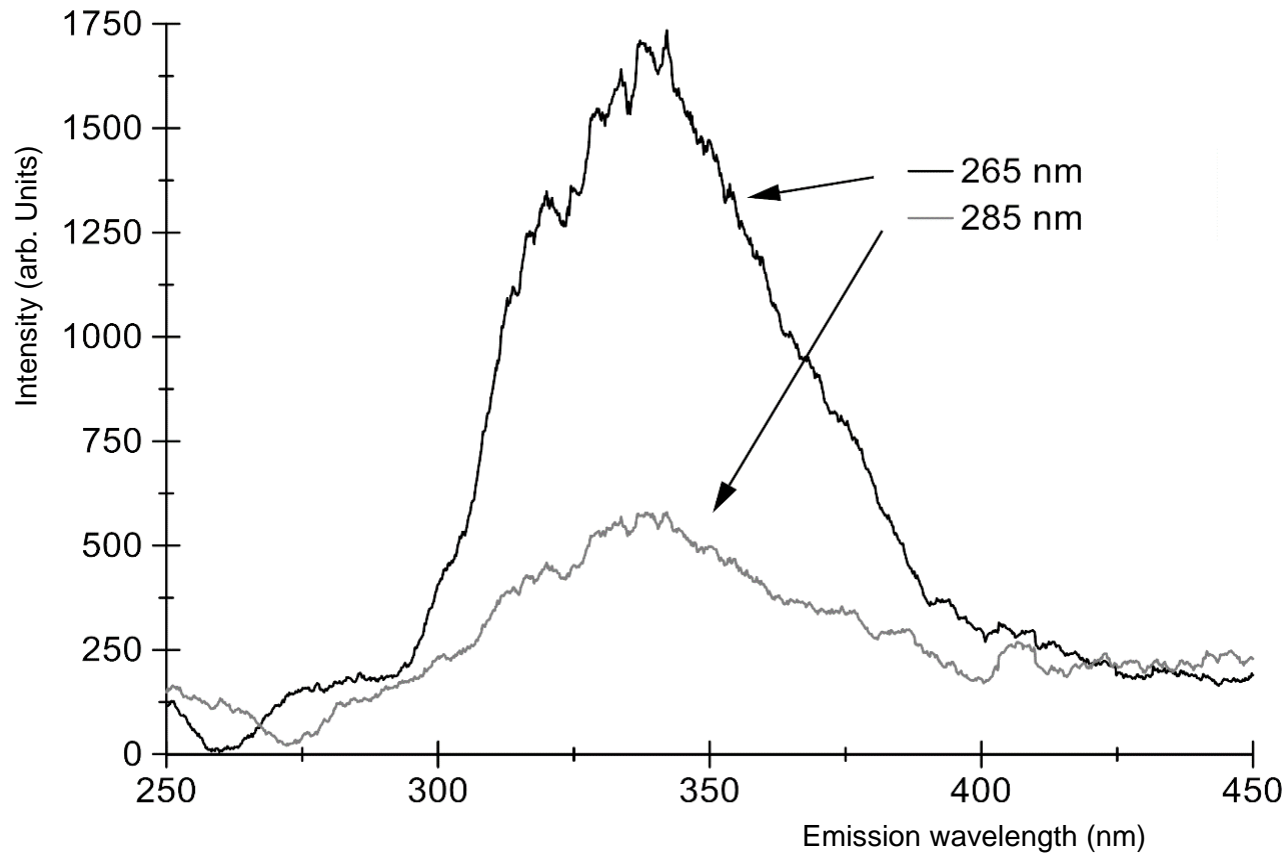
- Heated 'oven' for the producer gas piping
- Light source and MFCs next to the oven
- Data acquisition and power electronics



Tar Sensor - Setup

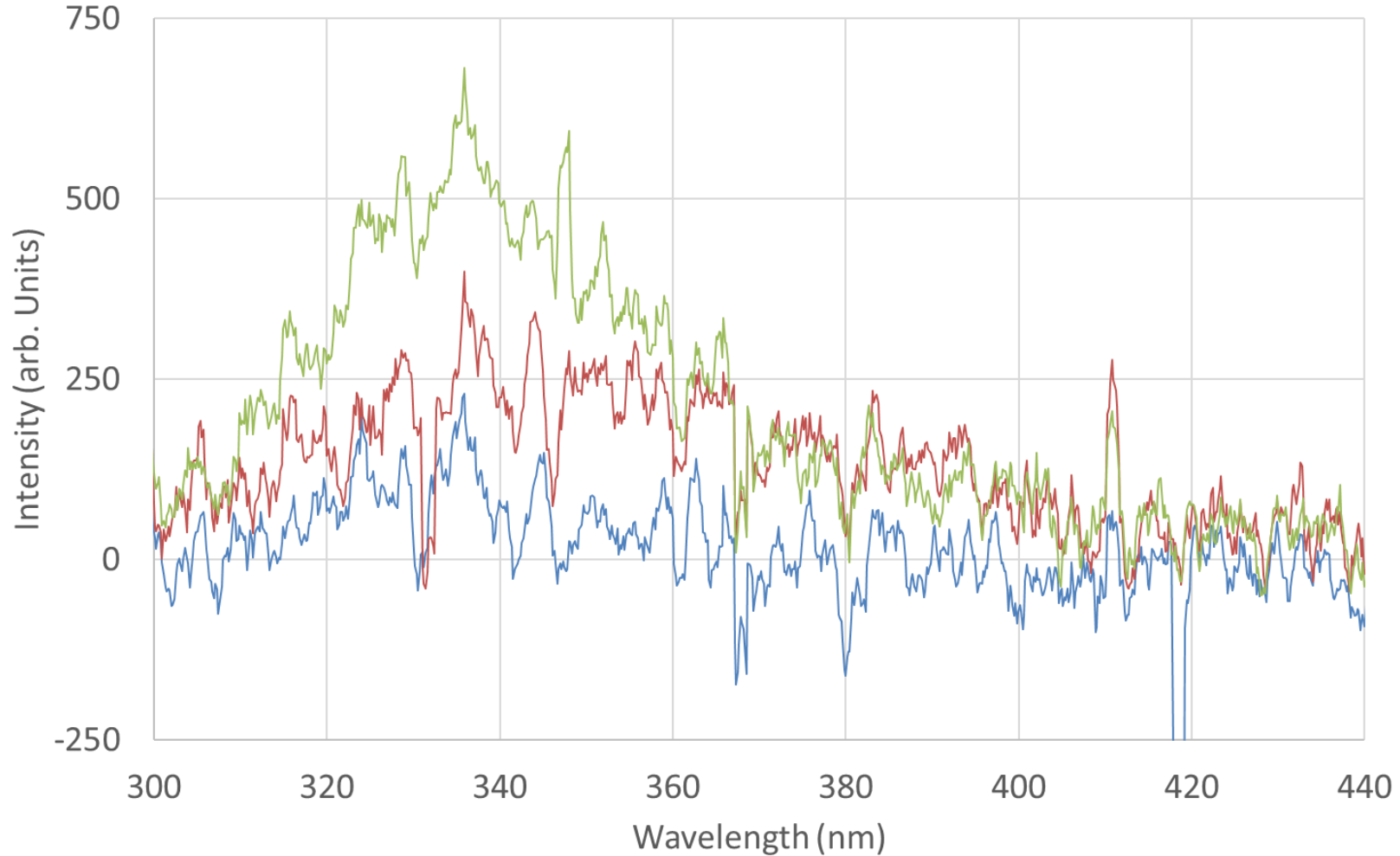


Tar Sensor - Measurements



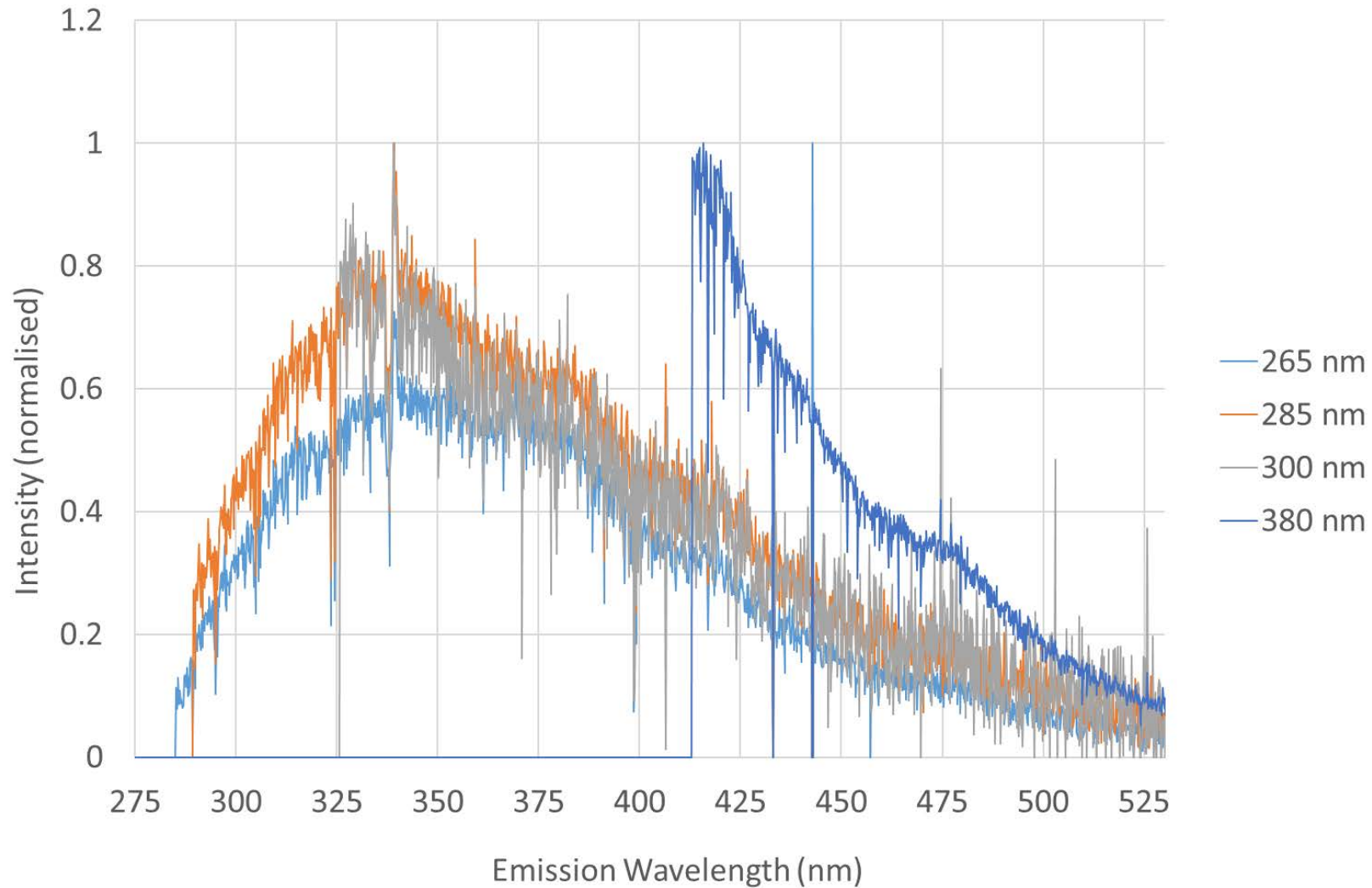
Naphthalene + Phenanthrene 3:1 in Nitrogen

Tar Sensor - Measurements



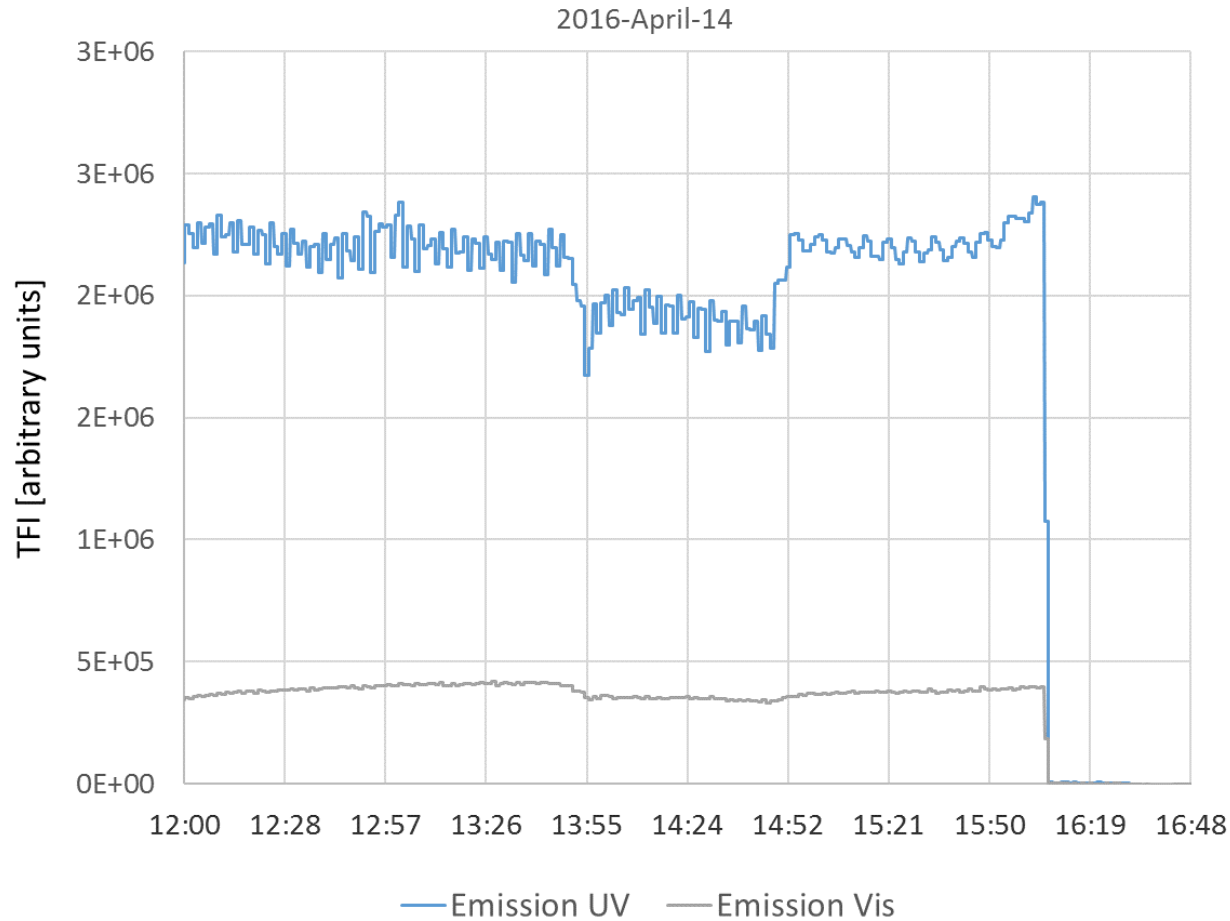
— Naphthalene 15g/Nm³ — Phenanthrene 5 g/Nm³ — Naphthalene + Phenanthrene

Tar Sensor - Measurements



Measurements in a 1 MW gasifier producer gas with four different wavelengths

Tar Sensor - Measurements



Measurements in a 1 MW gasifier producer gas with single wavelength excitation and evaluation of the signal in two wavelength regions

Summary

- A working setup with very little service requirements and easy integration into existing plant systems was proven to be working
- Further improvements to obtain less noisy data and to achieve better repeatability are necessary
- Possibilities to draw conclusions from the fluorescence signal to tar load have to be evaluated
- Evaluation of process control strategies based on the tar load of the producer gas
- Measurement campaigns at a larger gasifier coming up