Technische Universität Berlin

On-Line Tar Monitoring using Light Induced Fluorescence

Julian Borgmeyer | Gas Analysis Workshop | Berlin, 07.09.2017

EVUR

Agenda

- Existing Technology
- Setup of the Tar Sensor
- Measurement Principle and Limitations
- Results

Aktueller Forschungsstand

Technology	Developers	Interval	Endurance, service needs and limitations	Wet/dry basis
Tar protocol	ECN	~ one hour + off-line analysis	Manual sampling, lab analysis	Dry
Solid phase absorption (SPA)	KTH	~ one minute + off-line analysis	Manual sampling, lab analysis	Dry
Tar dewpoint analyser	ECN	several minutes	Fouling on the sensor surface possible, no direct statement about tar concentration	(Wet)
Mass spectrometry	Several	seconds	Different Technologies with different assets and drawbacks	Wet
High Temperature Reactor (HTR)	Chalmers U.	minutes	Delicate high-temperature equipment	Dry
flame ionization detector (FID)	U. of Stuttgart	~ one minute	Filter change necessary	Wet
Liquid UV-Vis	PSI	seconds	Solvent consumption, measurement error possible if tar composition changes	Dry
Gas-phase absorption	U. of Bolzano DTU	seconds	Measurement error possible if tar composition changes	Wet
Photo ionization detector (PID)	KTH / BTG	seconds	Fouling of the UV lamp is problematic, measurement error possible if tar composition changes	Wet
Light induced fluorescence (LIF)	TU Graz TU Munich TU Berlin	seconds	Measurement error possible if tar composition changes, fouling on windows is problematic, can usually only measure 2-ring and heavier tars	Wet

Research Questions

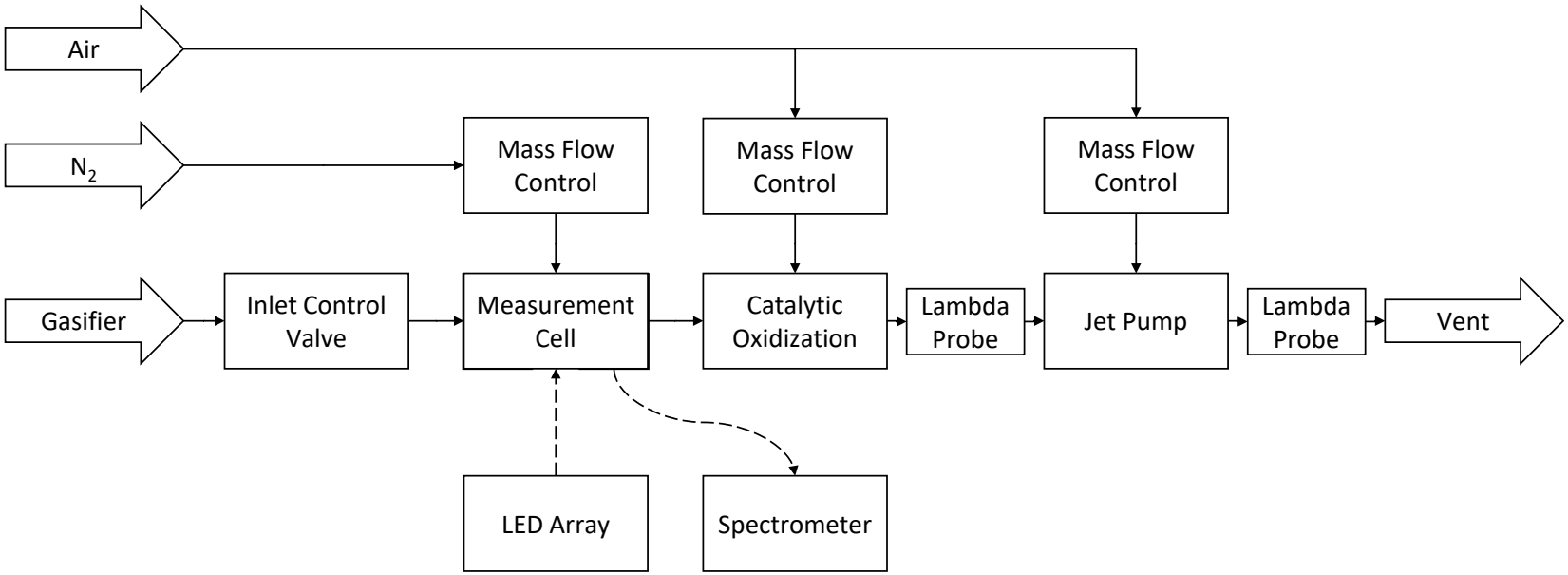
- **Is it possible to have a setup that meets the usual requirements for a quantitative measuring instrument?**
  - **Linear signal (or known function)**
  - **Repeatability**
  - **Low maintenance**

- **What limits remain?**

- **Which applications are advisable?**
  - **Gasifier control**
  - **Monitoring of down-stream equipment**
  - **Monitoring of the fuel quality**

Challenges and Setup

- Avoid condensation at optical access windows
  - Flushing with nitrogen
- Adjustable gas flow
- Oxidation of the gas after measurement (→chimney)
- Stable, robust light source



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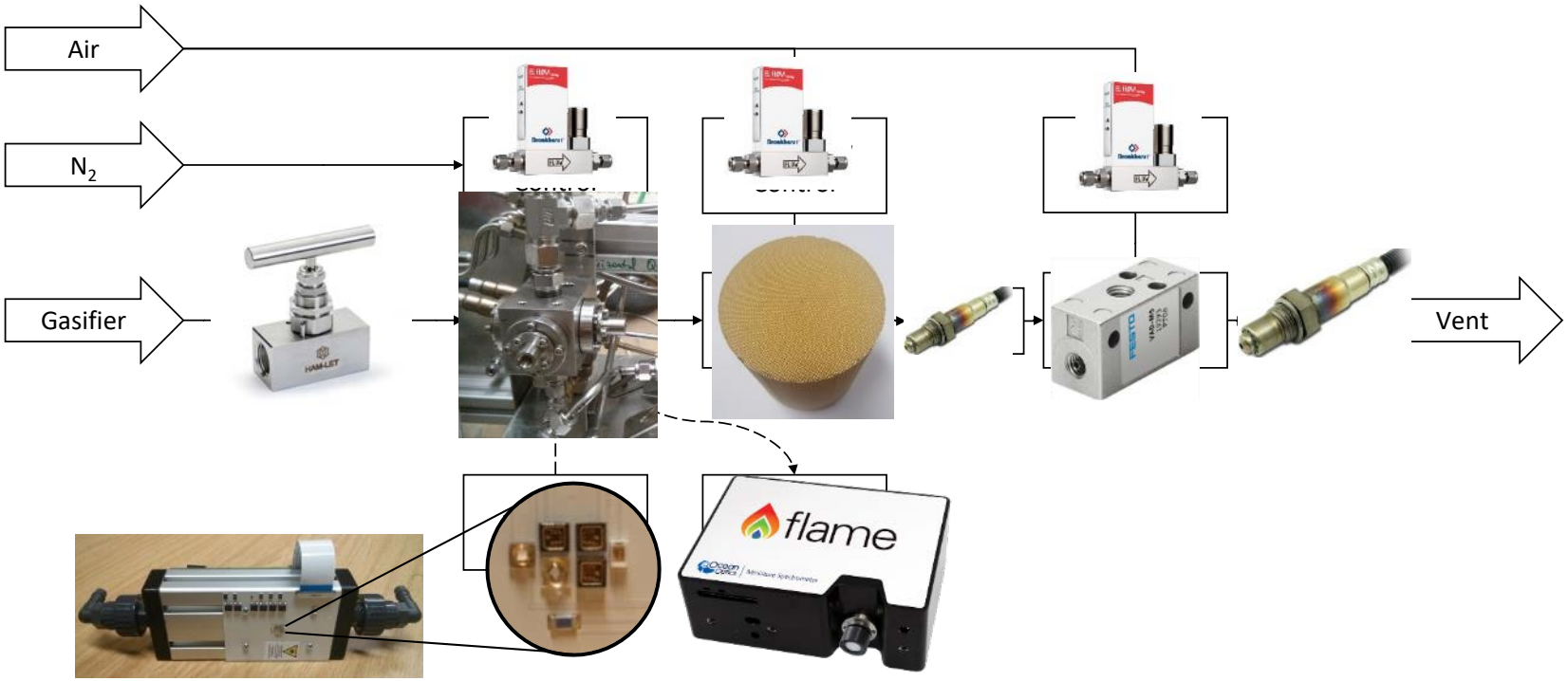
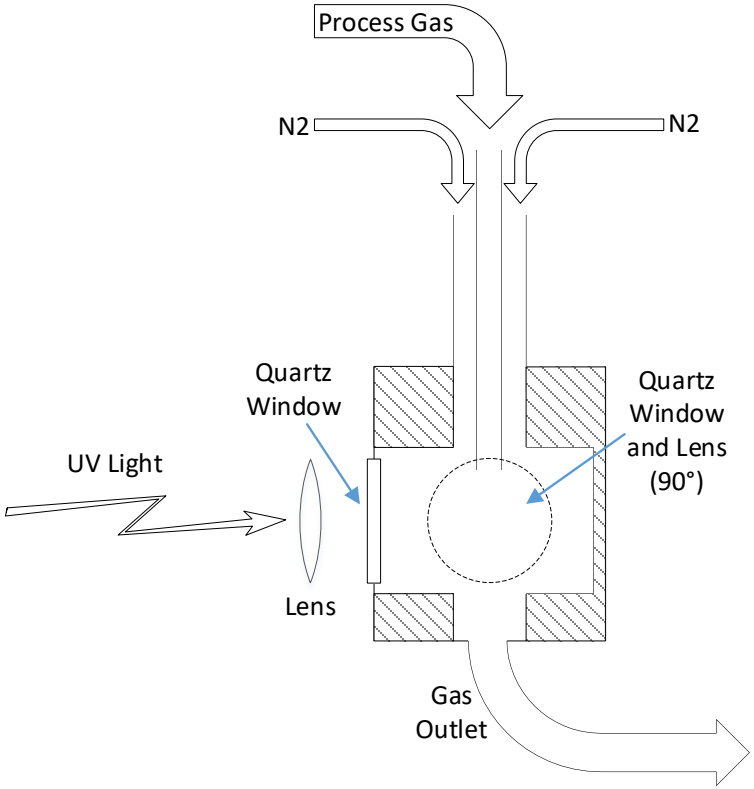
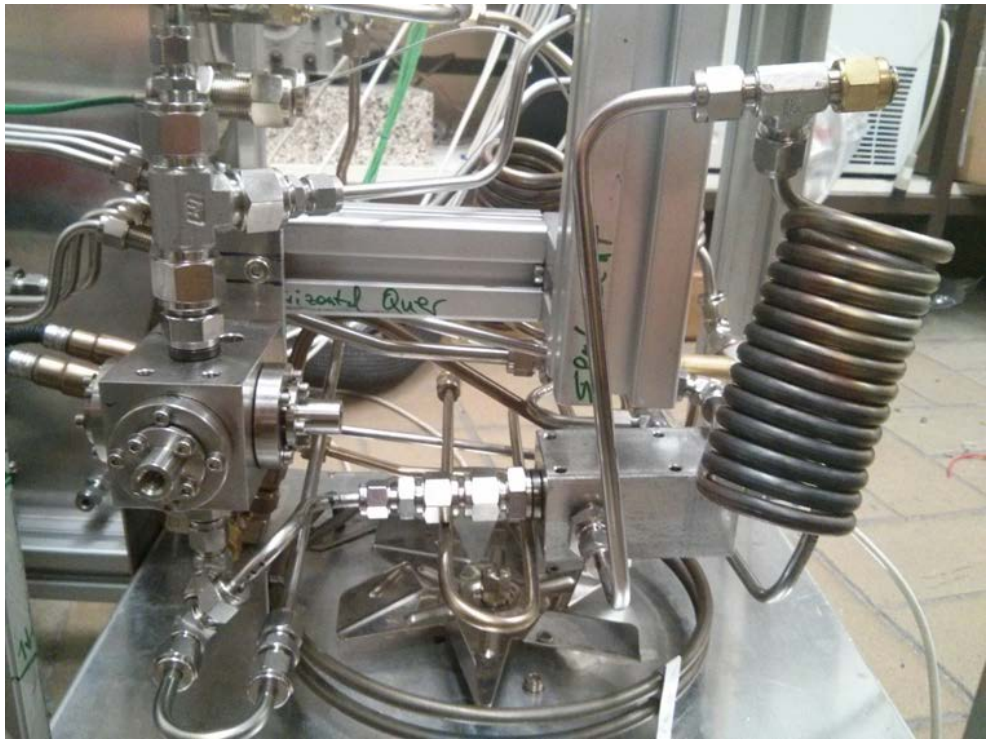
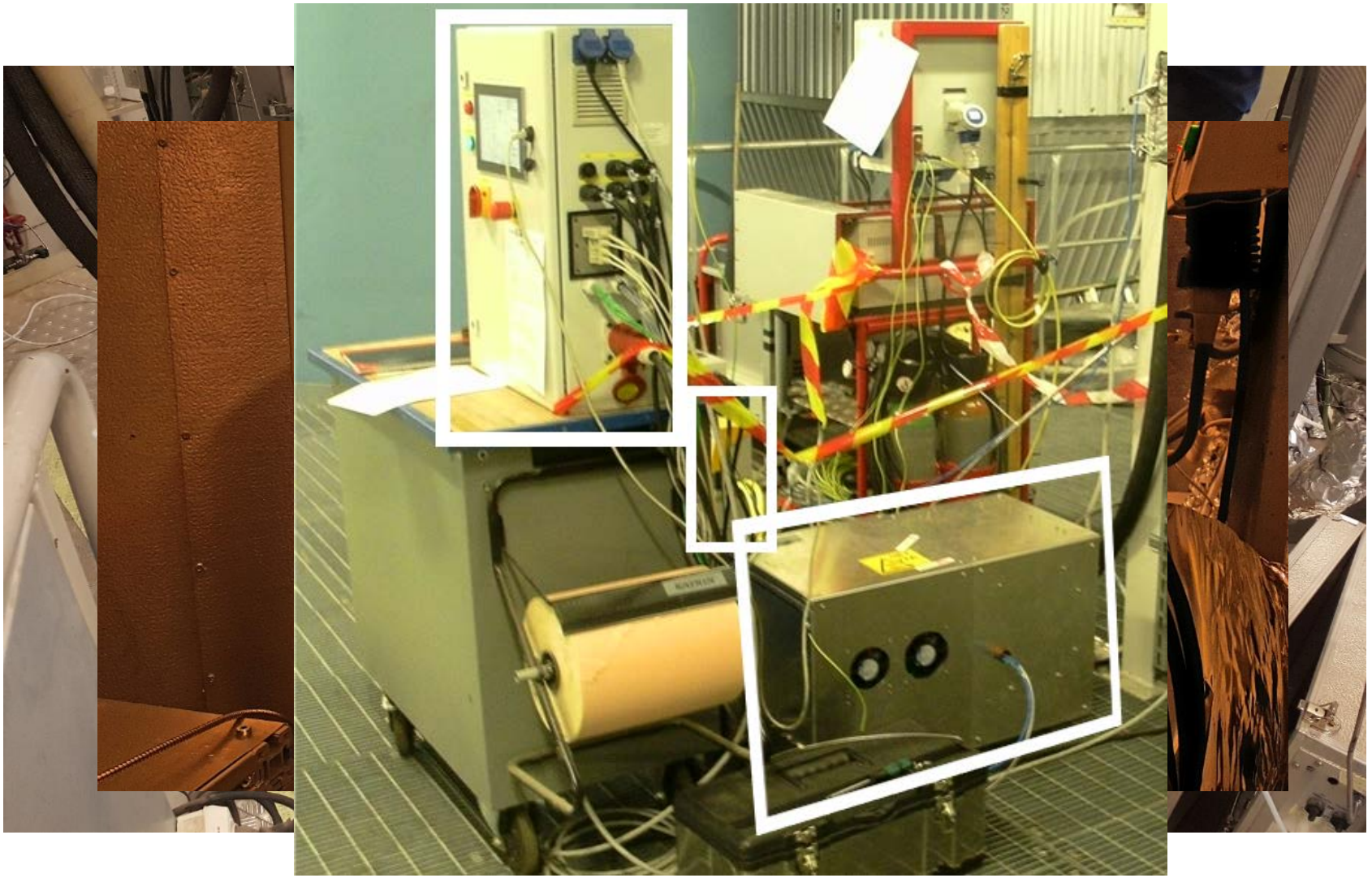


Setup


Process Gas
N2
N2
Quartz Window
Quartz Window and Lens (90°)
UV Light
Lens
Gas Outlet

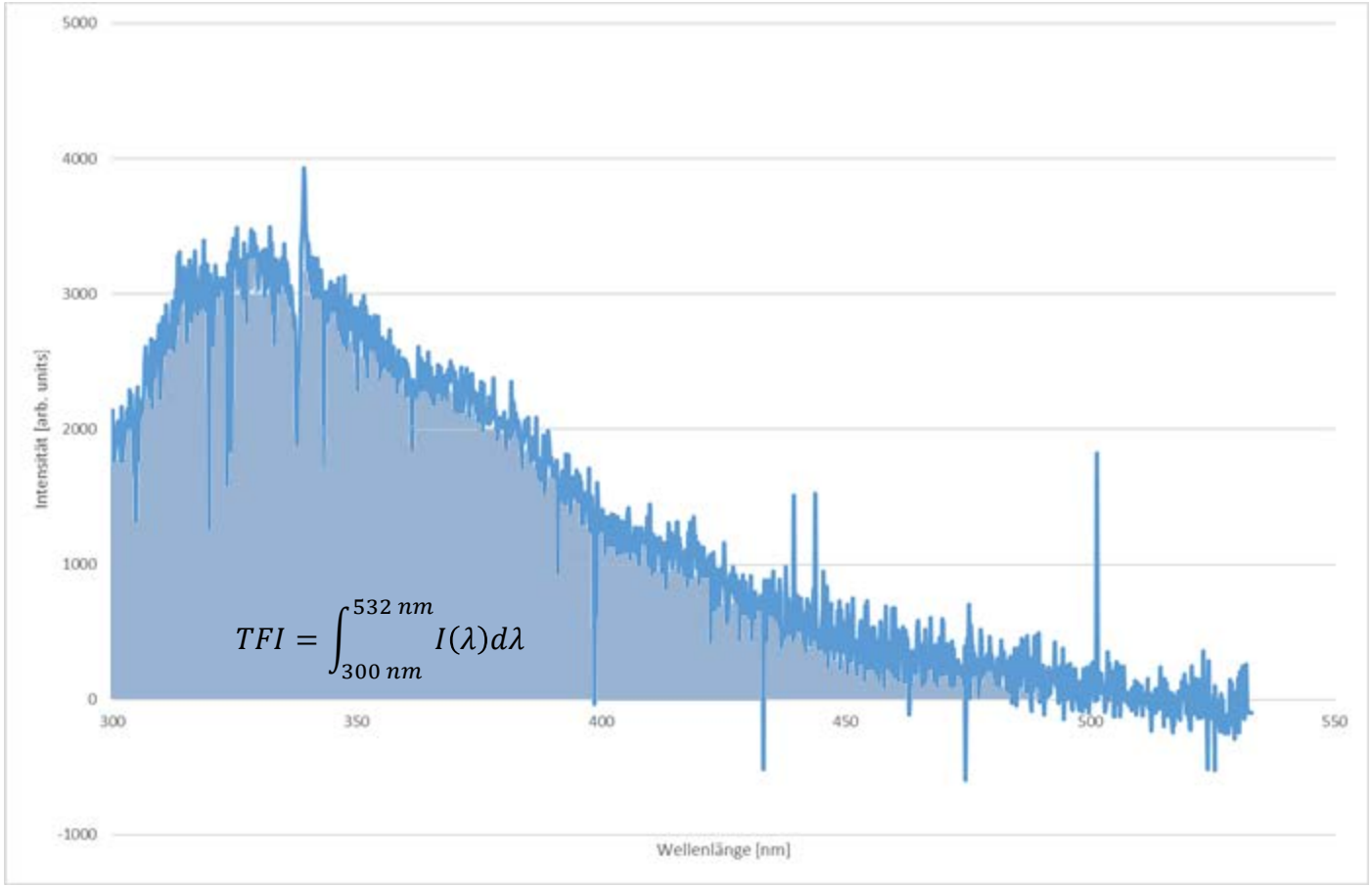


Setup



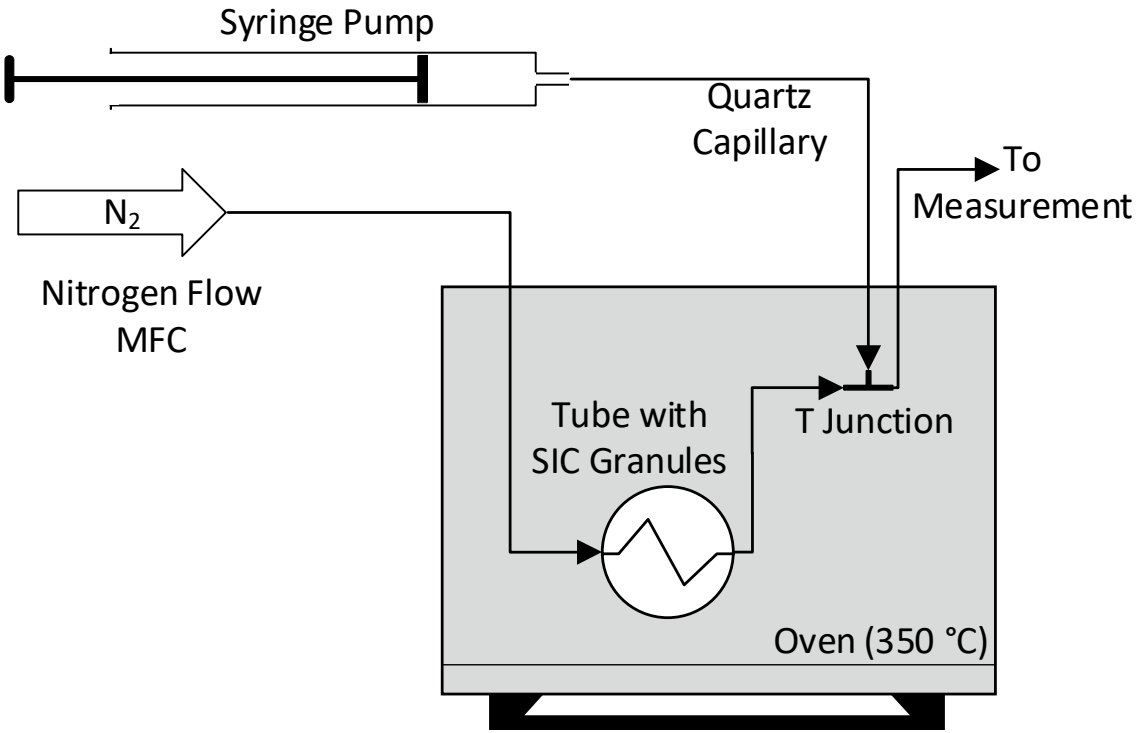
Measurement Principle

- **Example spectrum 'Total Fluorescence Intensity'**

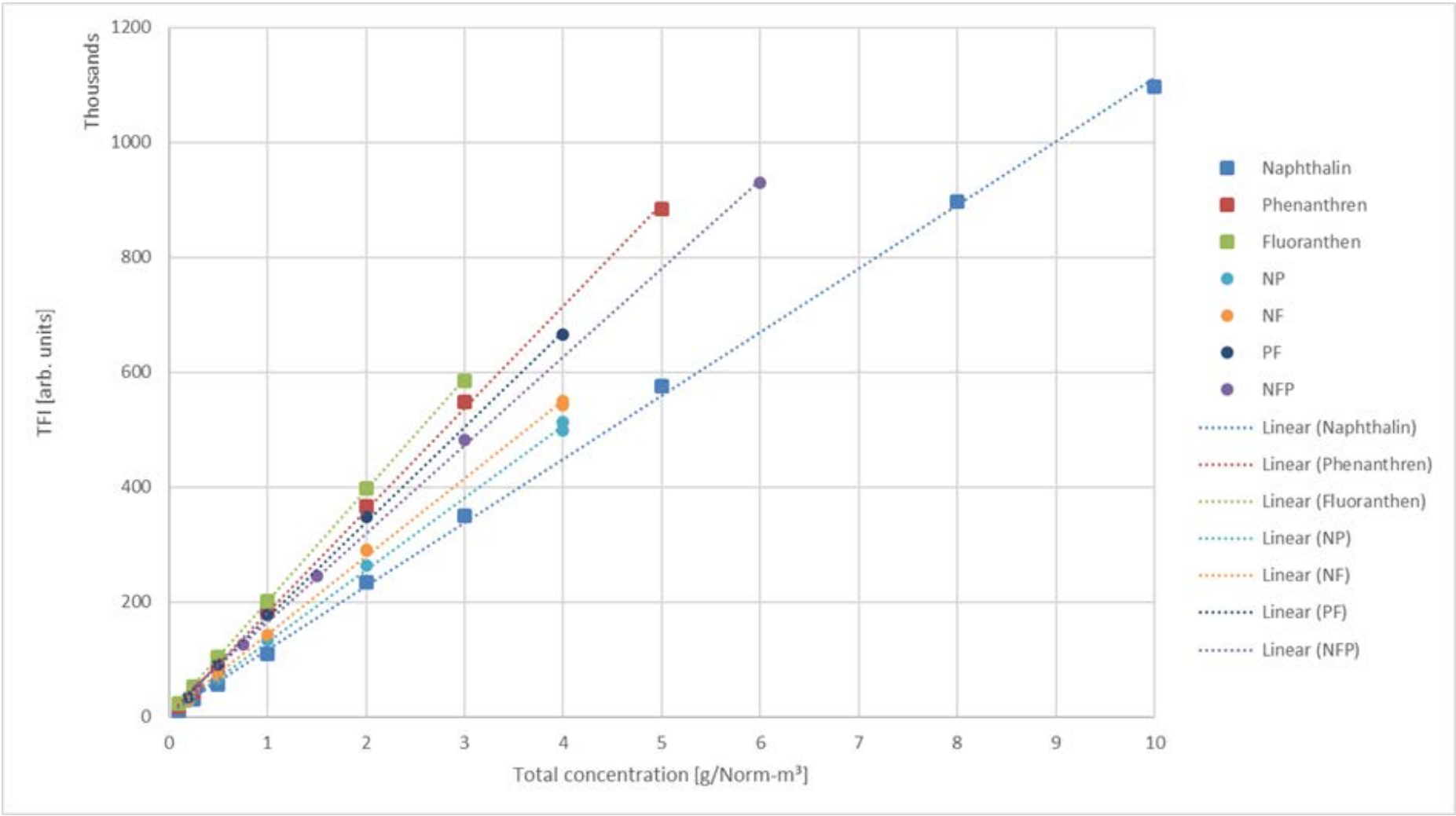


Measurement Principle

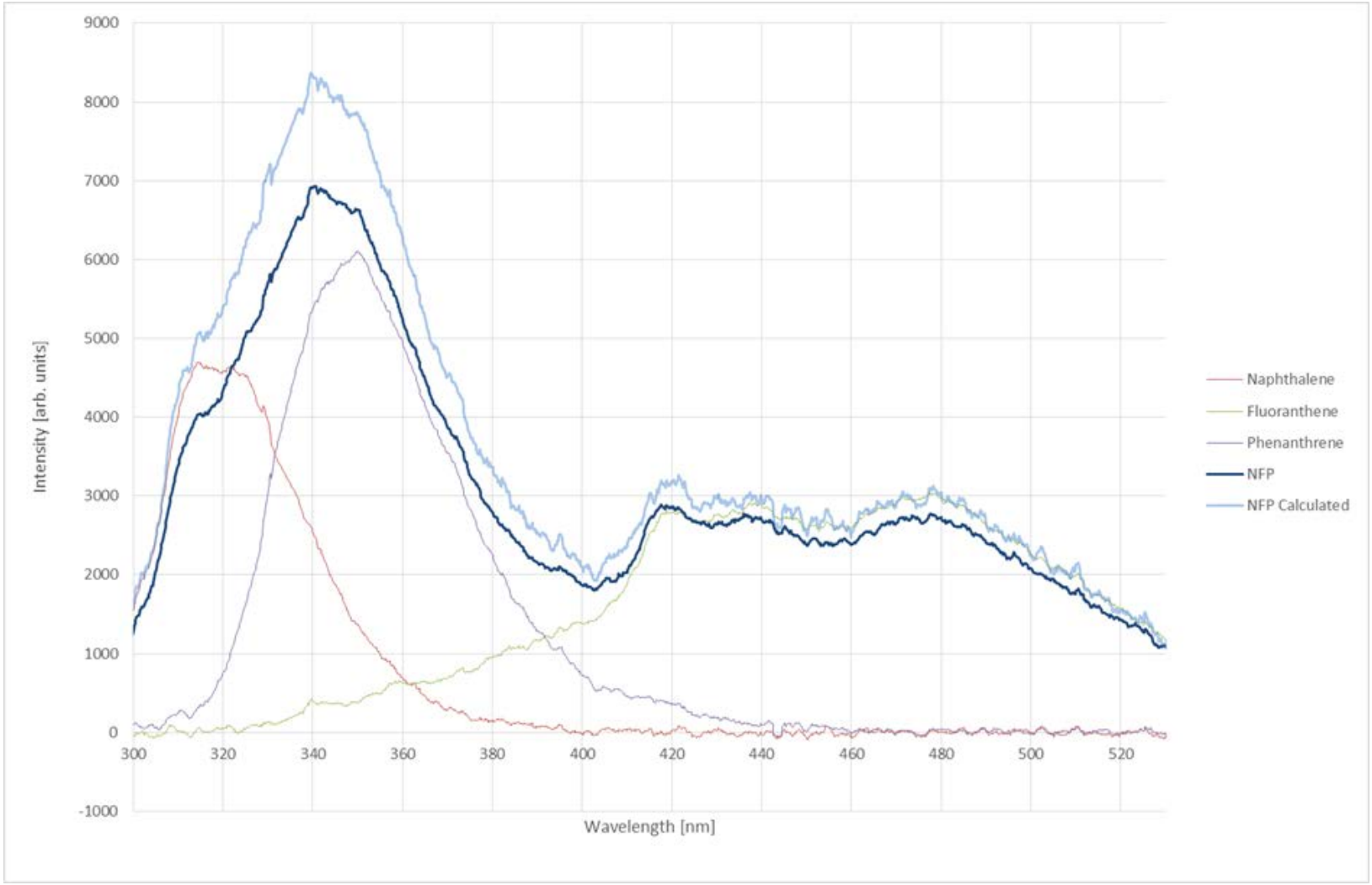
- **Test gas generation**



Measurement Principle



Measurement Principle

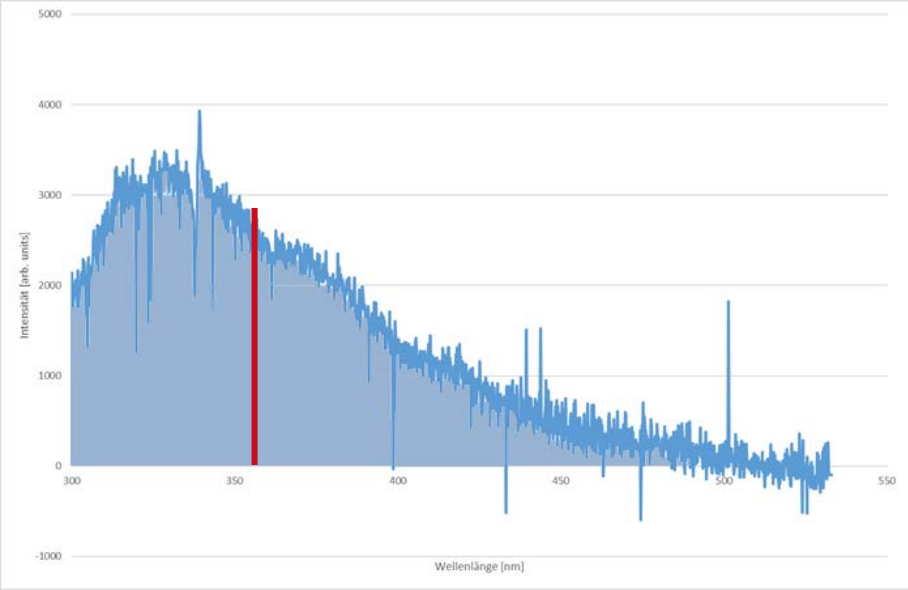


Measurement Principle

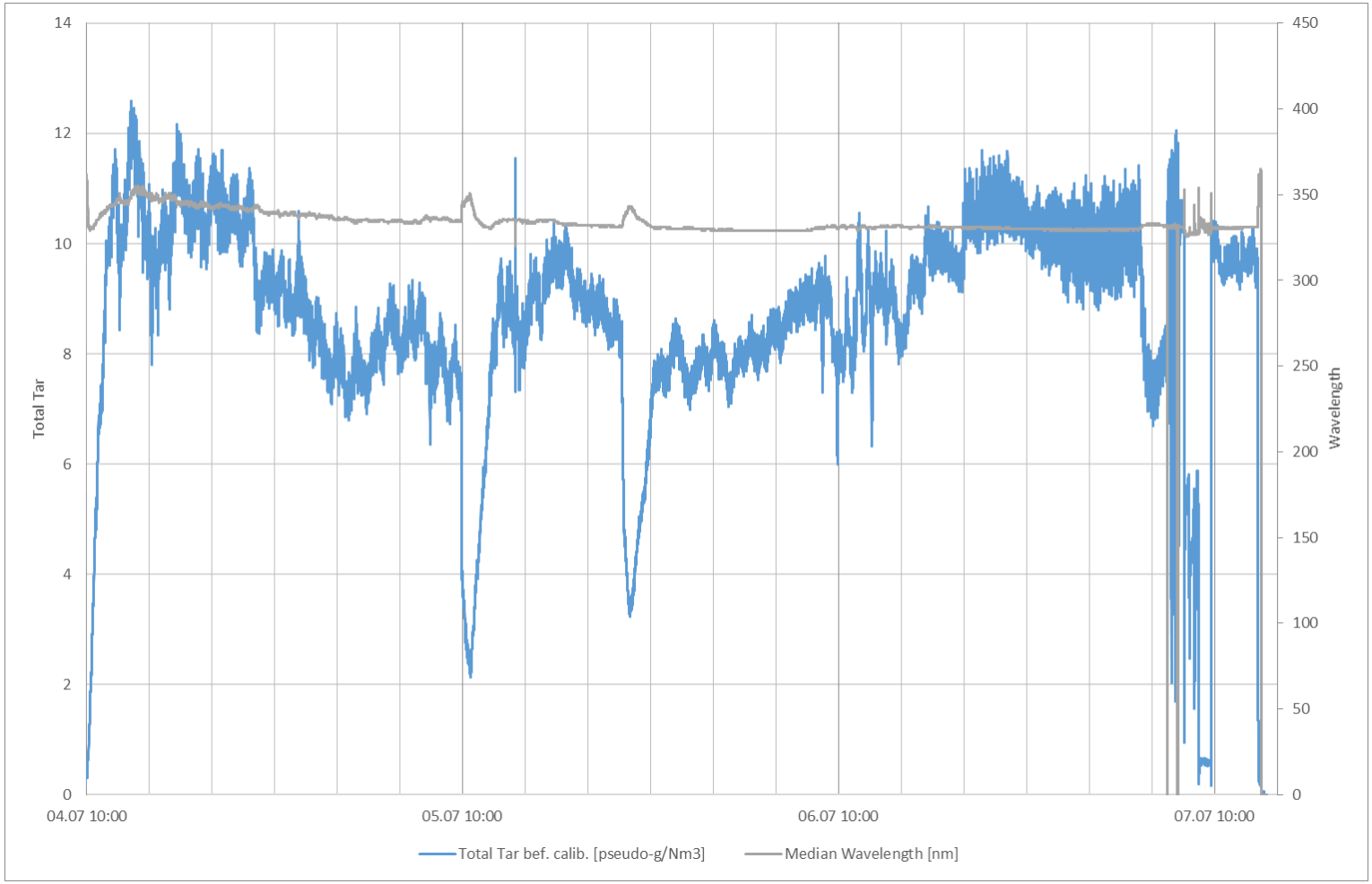
- **TFI → Sensor Signal**

$$Sensor\ Signal = \frac{1\ bar}{p} \cdot \sum_{i=a_1}^{a_2} C(i) \cdot r\big(\lambda(i)\big)$$

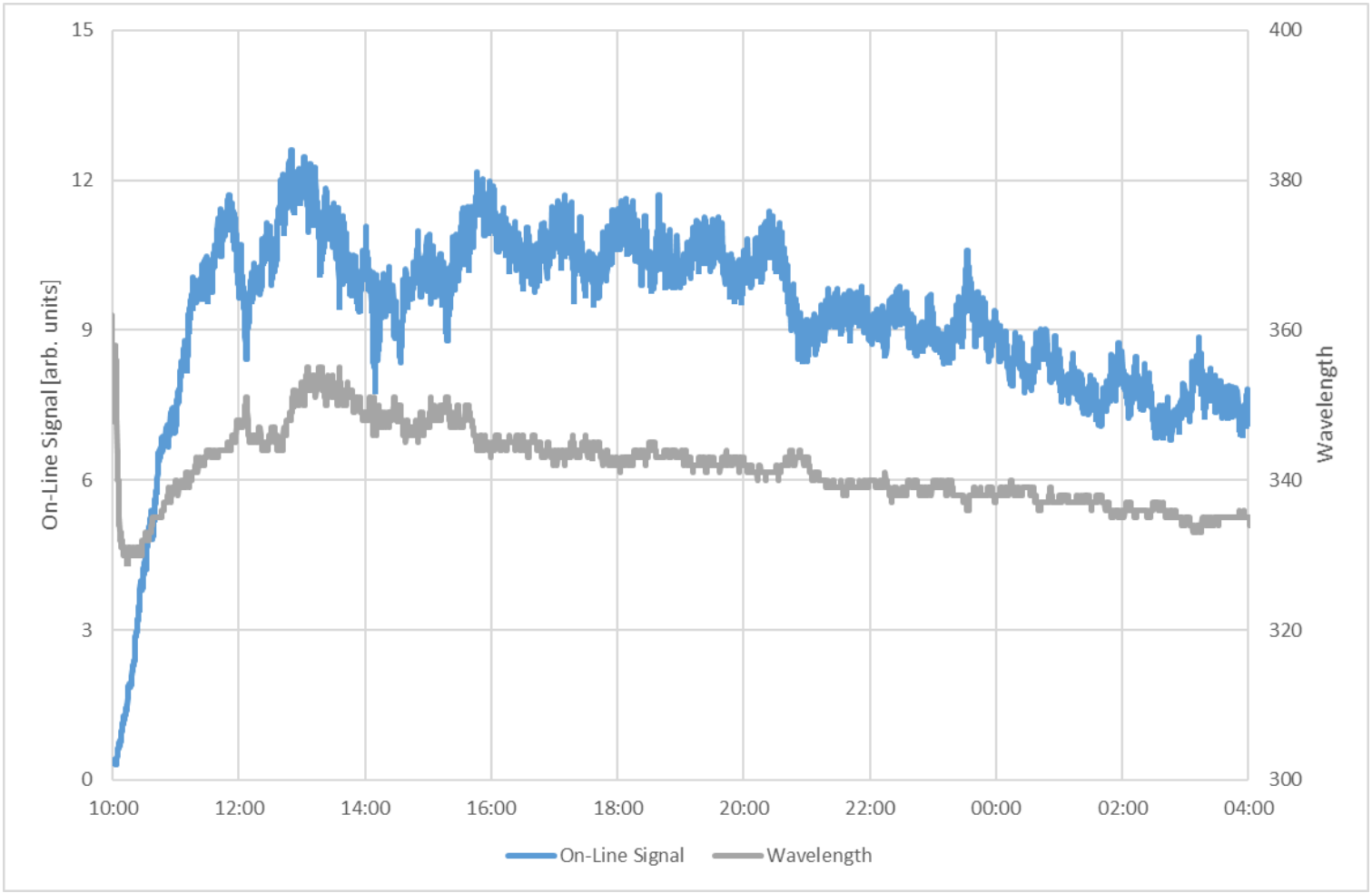
- **Additional Information: Median Wavelength**



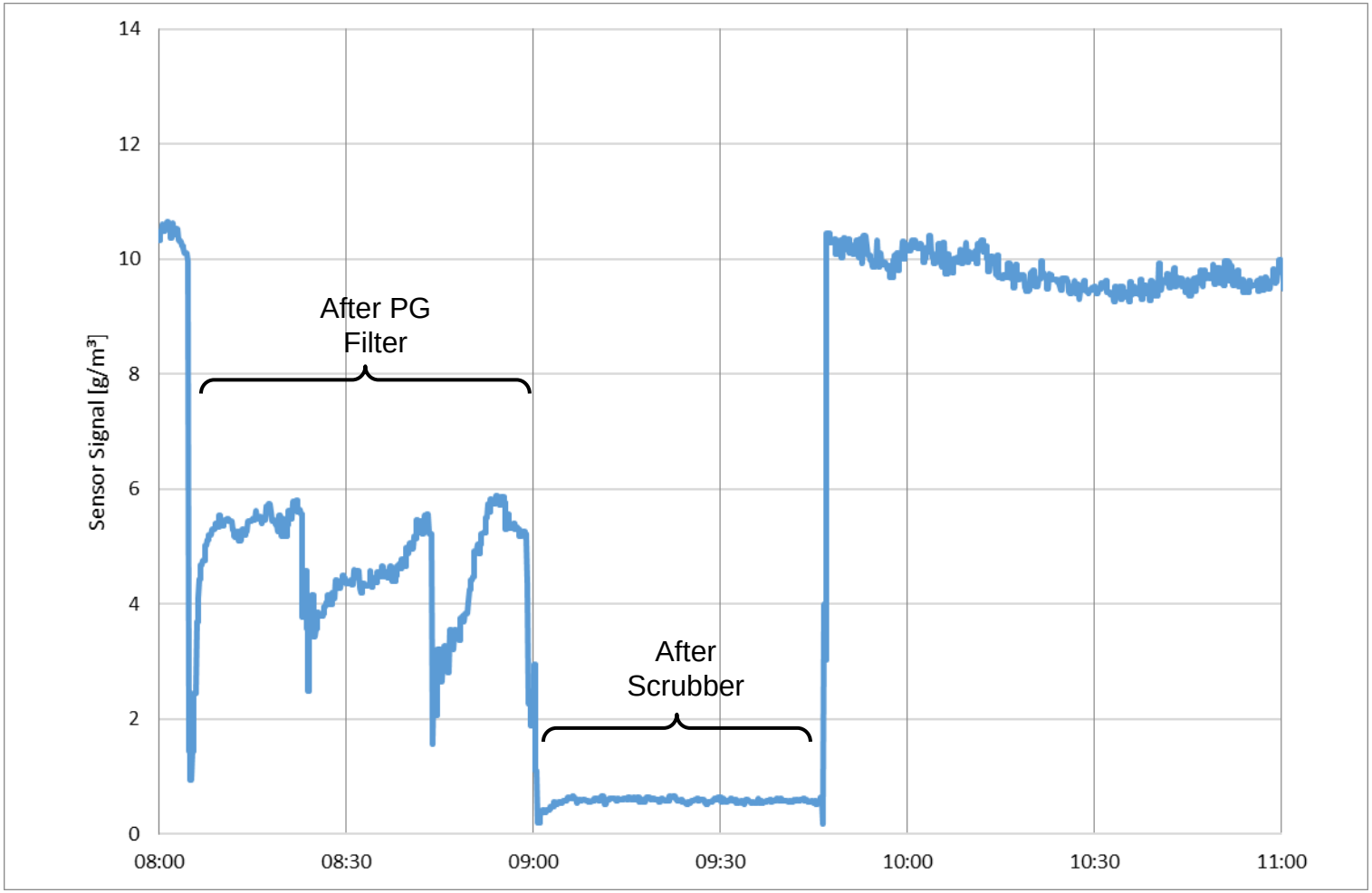
Results


14
12
10
8
6
4
2
0
Total Tar
450
400
350
300
250
200
150
100
50
0
Wavelength
04.07 10:00
05.07 10:00
06.07 10:00
07.07 10:00
Total Tar bef. calib. [pseudo-g/Nm3]
Median Wavelength [nm]

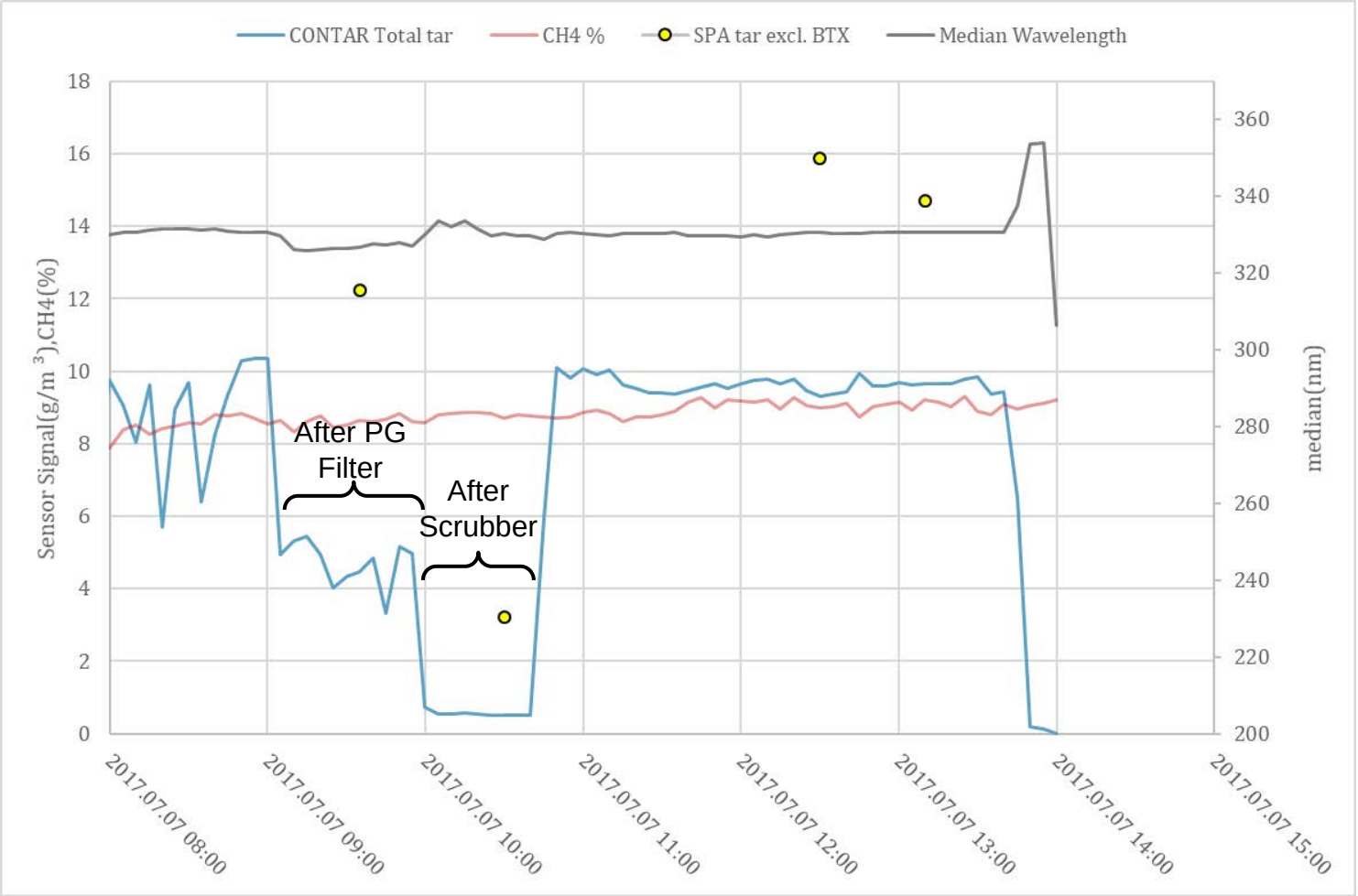
Results


15
12
9
6
3
0
On-Line Signal [arb. units]
400
380
360
340
320
300
Wavelength
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00
02:00
04:00
On-Line Signal
Wavelength

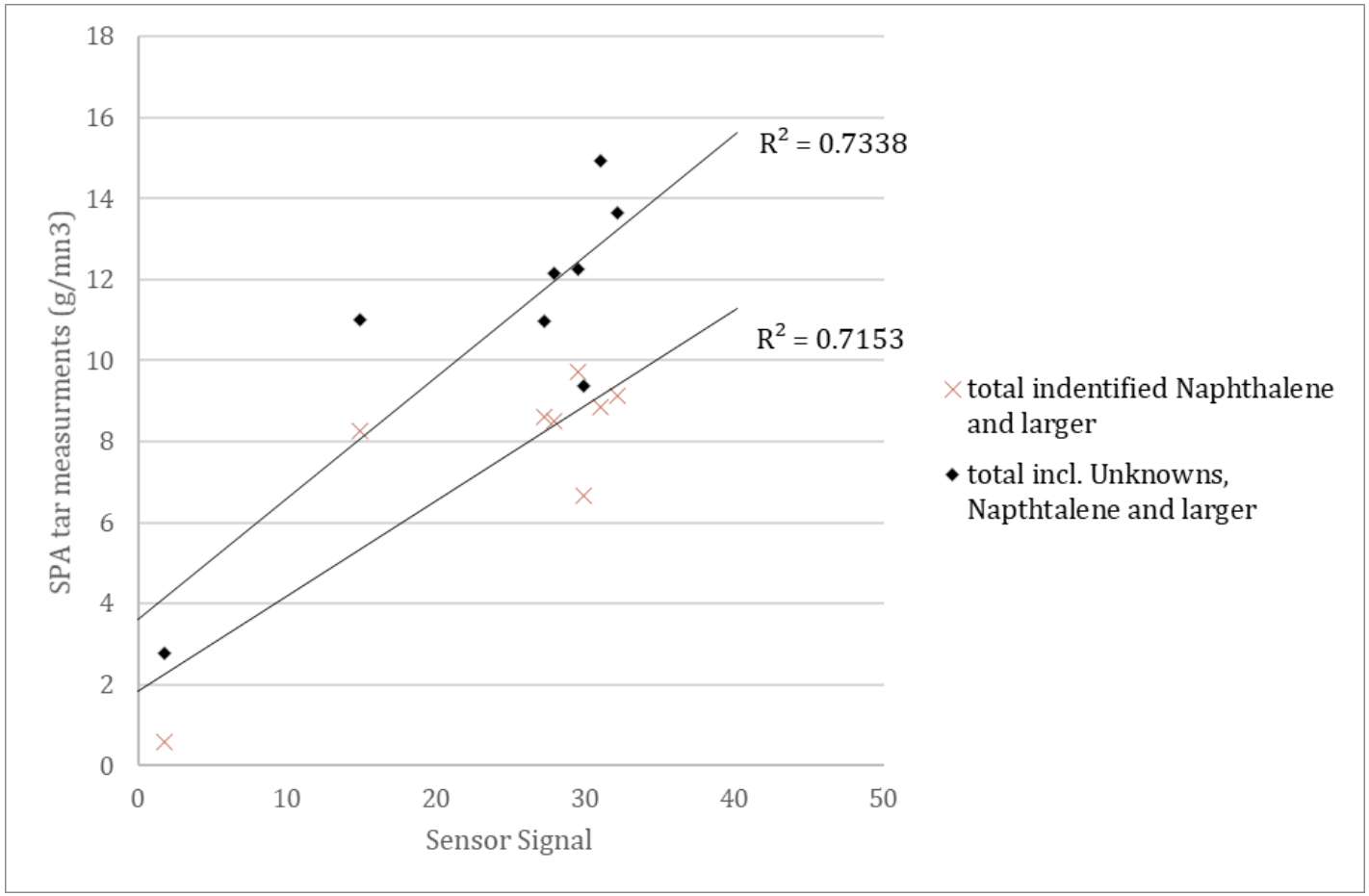
Results


14
12
10
8
6
4
2
0
Sensor Signal [g/m³]
After PG Filter
After Scrubber
08:00
08:30
09:00
09:30
10:00
10:30
11:00

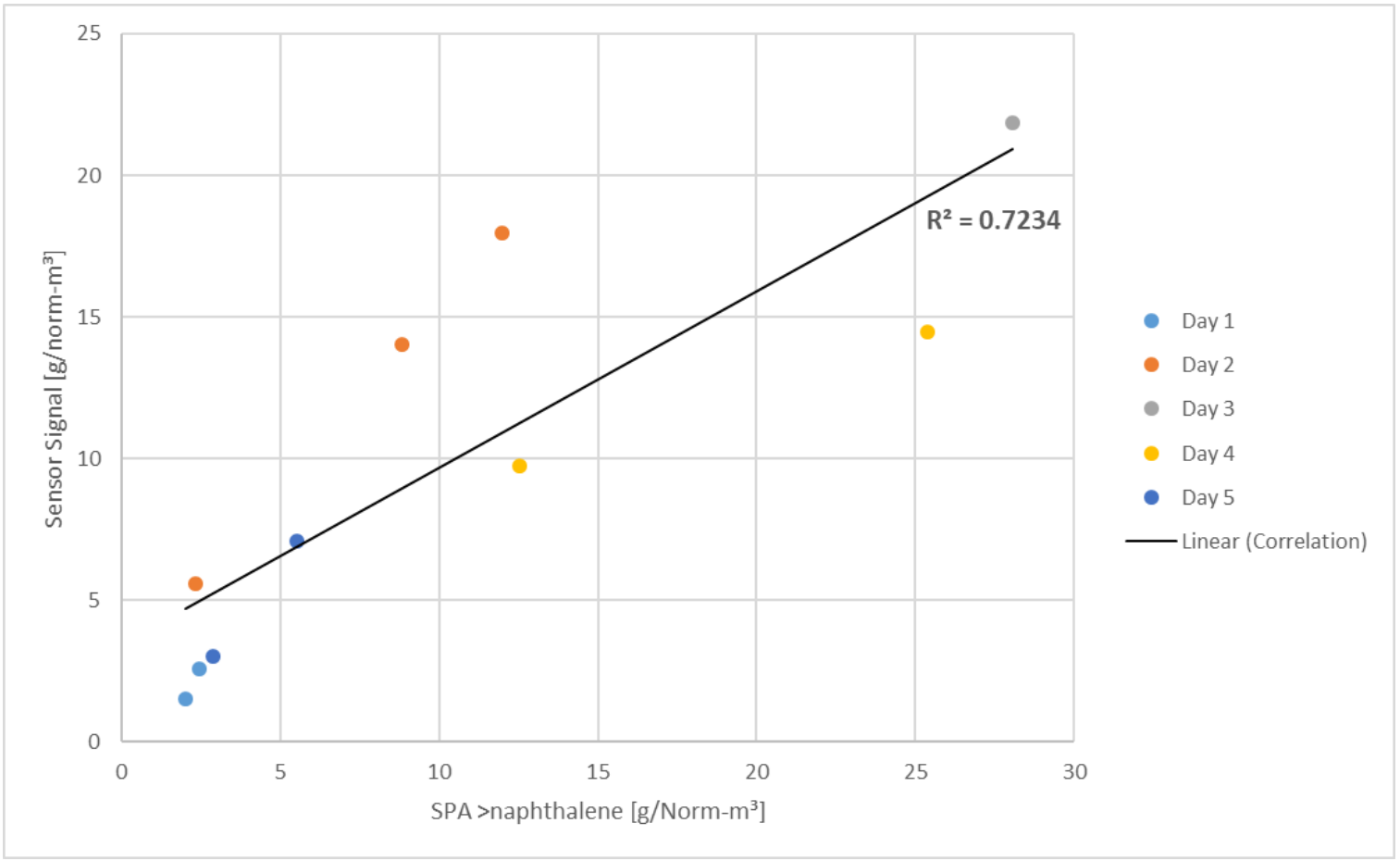
Results


CONTAR Total tar
CH4 %
SPA tar excl. BTX
Median Wawelength
Sensor Signal(g/m 3),CH4(%)
median(nm)
After PG Filter
After Scrubber
0
2
4
6
8
10
12
14
16
18
200
220
240
260
280
300
320
340
360
2017.07.07 08:00
2017.07.07 09:00
2017.07.07 10:00
2017.07.07 11:00
2017.07.07 12:00
2017.07.07 13:00
2017.07.07 14:00
2017.07.07 15:00

Results


SPA tar measurments (g/mn3)
Sensor Signal
0
2
4
6
8
10
12
14
16
18
0
10
20
30
40
50
R² = 0.7338
R² = 0.7153
total indentified Naphthalene and larger
total incl. Unknowns, Napthtalene and larger

Results


25
20
15
10
5
0
0
5
10
15
20
25
30
Sensor Signal [g/norm-m³]
SPA >naphthalene [g/Norm-m³]
R² = 0.7234
Day 1
Day 2
Day 3
Day 4
Day 5
Linear (Correlation)

Summary

- Low maintenance
  ✓
- Repeatability
  ✓
- Linear Signal
  (✓)
- Limits
  - Tar composition changes
  - Steam content
- Possible Applications
  - Gasifier control, up- and down-stream monitoring
    Being evaluated

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