Correlation between Pegasor Particle Sensor and Particle Number Counter
Application of Pegasor Particle Sensor in Heavy Duty Exhaust

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The implementation of a particle number limit by Euro VI has lead to the development of an "appropriate" measurement method. This method affords the sampling from diluted engine exhaust and the usage of a complex sample treatment before measurement in a particle number counter. The commercial setups are cost intensive and more over bulky. For engine development another measurement system should be found. In the following studies a new in line sensor, developed by Pegasor was used in comparison with an AVL APC Advanced and an AVL Micro Soot Sensor.The studies have been performed in order to find similarities between the sensor signals. The tests were carried out with a heavy duty diesel EURO IV engine equipped with a continuously regenerating particle trap.

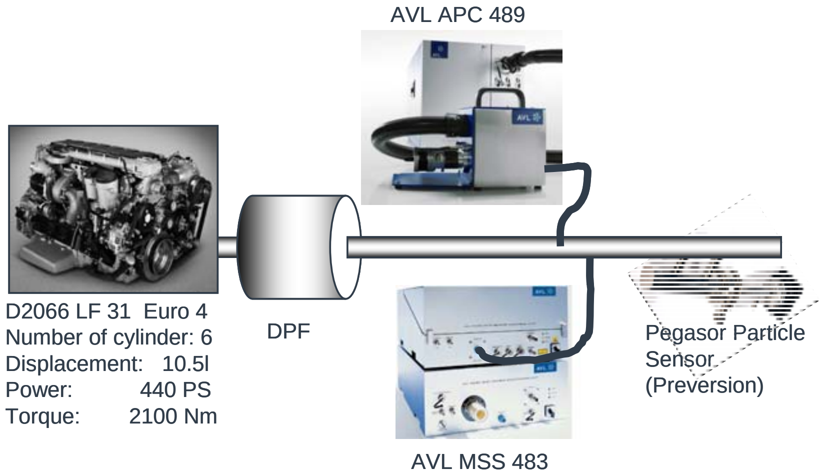

Figure 1: Schematic test setup.

The signal correlation has been investigated during several European Stationary and European Transient Cycles before and behind the particle trap.

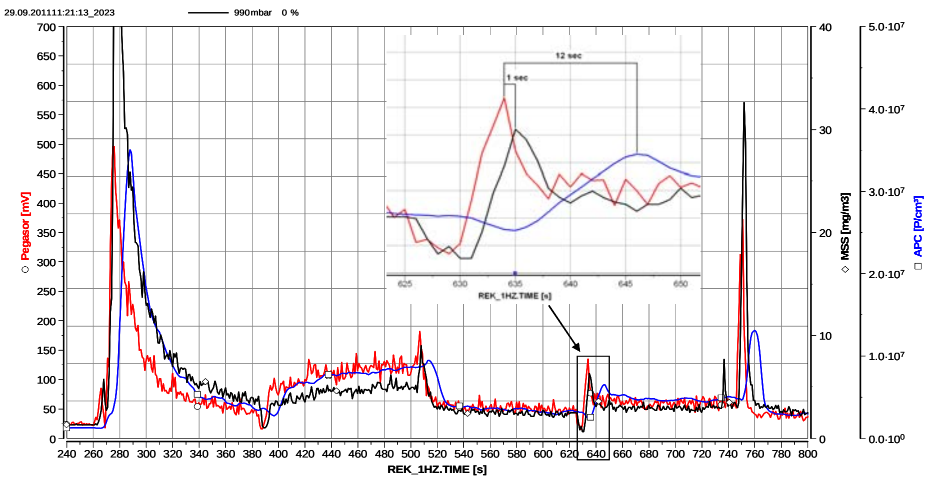

Figure 2: Signal of PPS, MSS and APC during a transient test cycle.

In transient tests the sensor showed a fast response time. The correlation of Pegasor signal to soot mass signal was found to be moderate, the correlation to particle number concentration was found to be good.

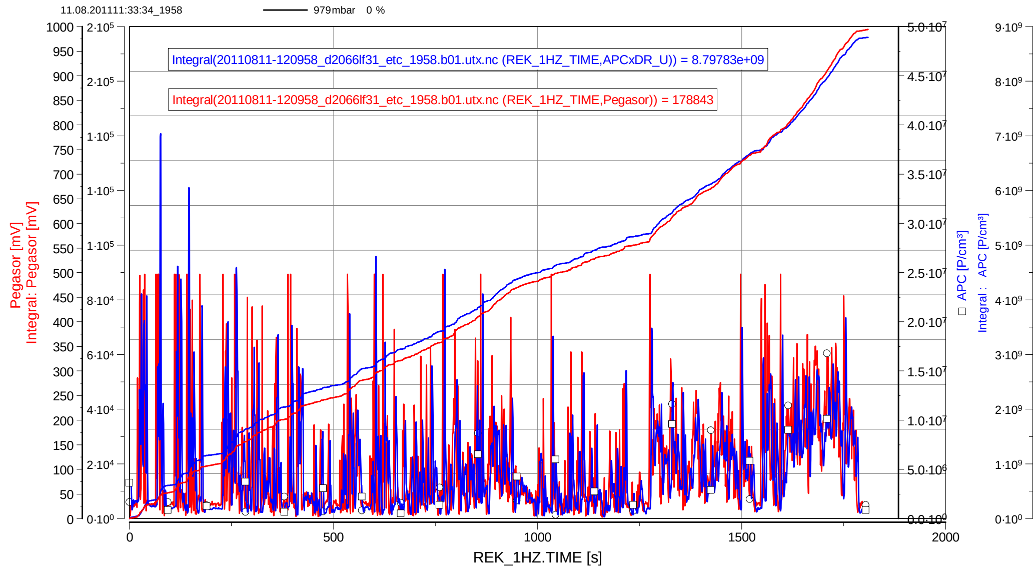

Figure 3: Correlation of PPS to APC during a European Test Cycle.

During the tests the Pegasor Particle Sensor showed a good signal correlation to MSS and APC. The signals were found to be reproducible. Moreover the sensor proved itself to be stable and robust und heavy duty diesel engine conditions.

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16th ETH Conference on Combustion Generated Nanoparticles,

June 24th – 27th 2012

Zurich ETH Zentrum, Main Building, HG E7

Agenda

1 Motivation

For EURO VI Homologation particle emission limits have to be fulfilled:

PN: $6 \cdot 10^{11}$ # kW h^{-1} (WHTC) and $8 \cdot 10^{11}$ # kW h^{-1} (WHSC)

PM: 10 mg kWh^{-1}

The proposed setup according to UN ECE Regulation 49 is bulky and cost intensive (Invest and life cycle cost)

Particle number concentration measurement according to UN ECE Regulation 49 has an impact on particle mass measurement with partial dilution systems

Demands from engineers for an alternative system:

Its signal should correlate with certification standard system

It should be able to measure transient cycles

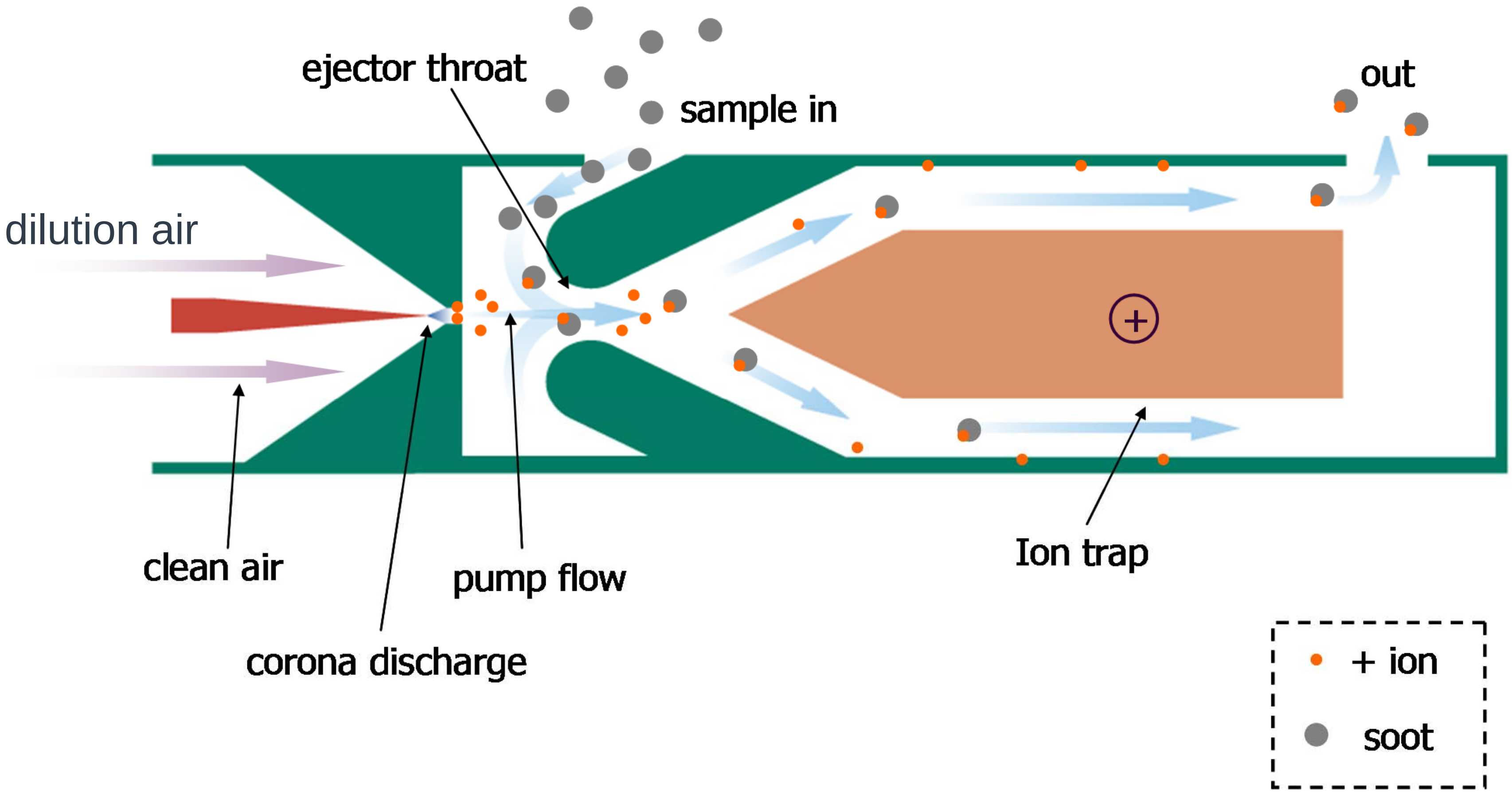
It should be small and robust (raw exhaust application)

It shall need little service effort (Cost effect in invest and life cycle),

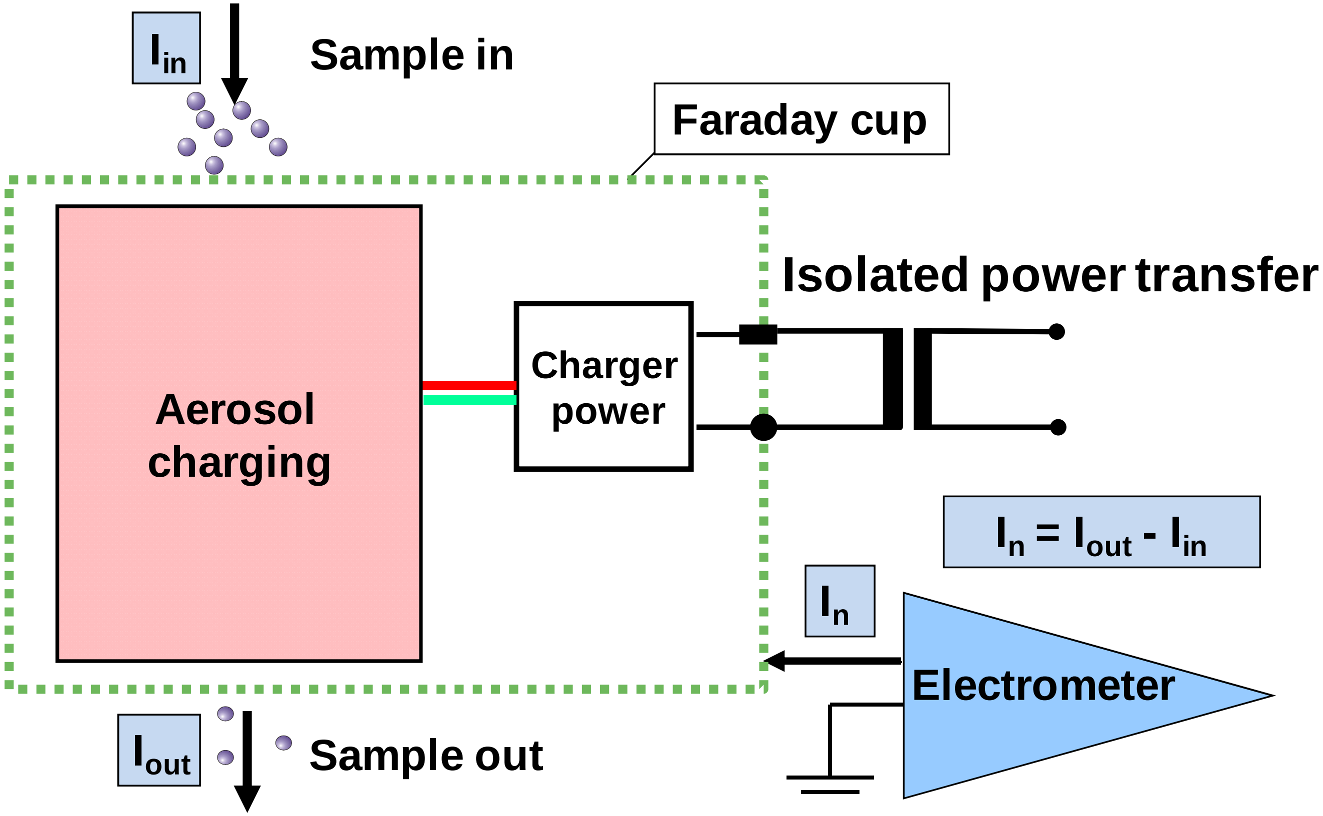
Easy operation (plug and play) should be ensured

Agenda

2 Peagasor Particle Sensor (1/3)
(Sensor Layout)

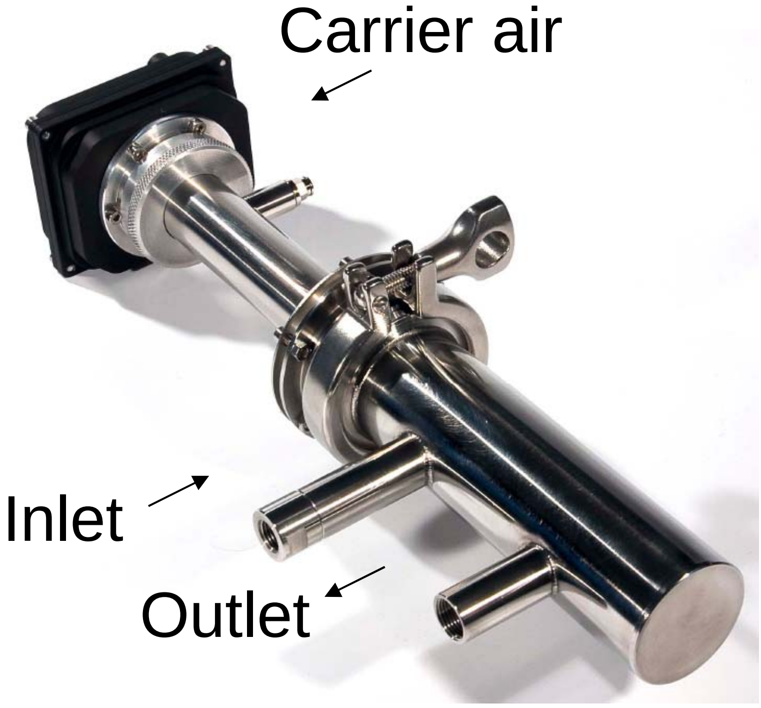


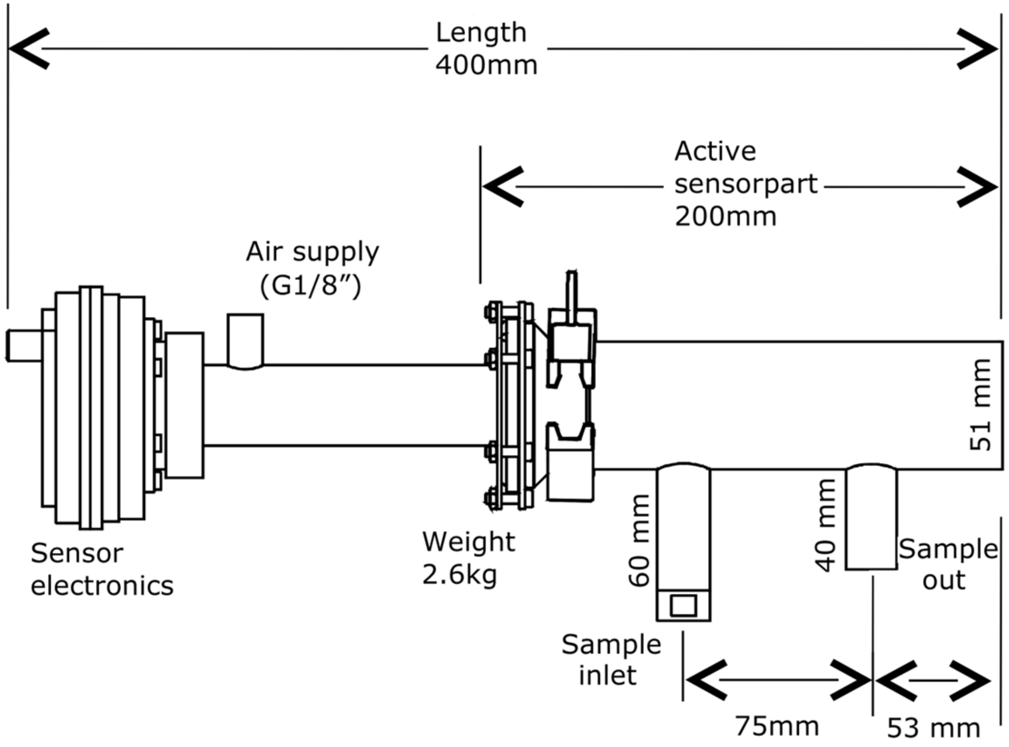
2 Pegasor Particle Sensor (2/3)
(Operating principle)



- Technique referred to as “Escaping Current”

2 Peagasor Particle Sensor (3/3)
(Sensor Physical Dimensions)



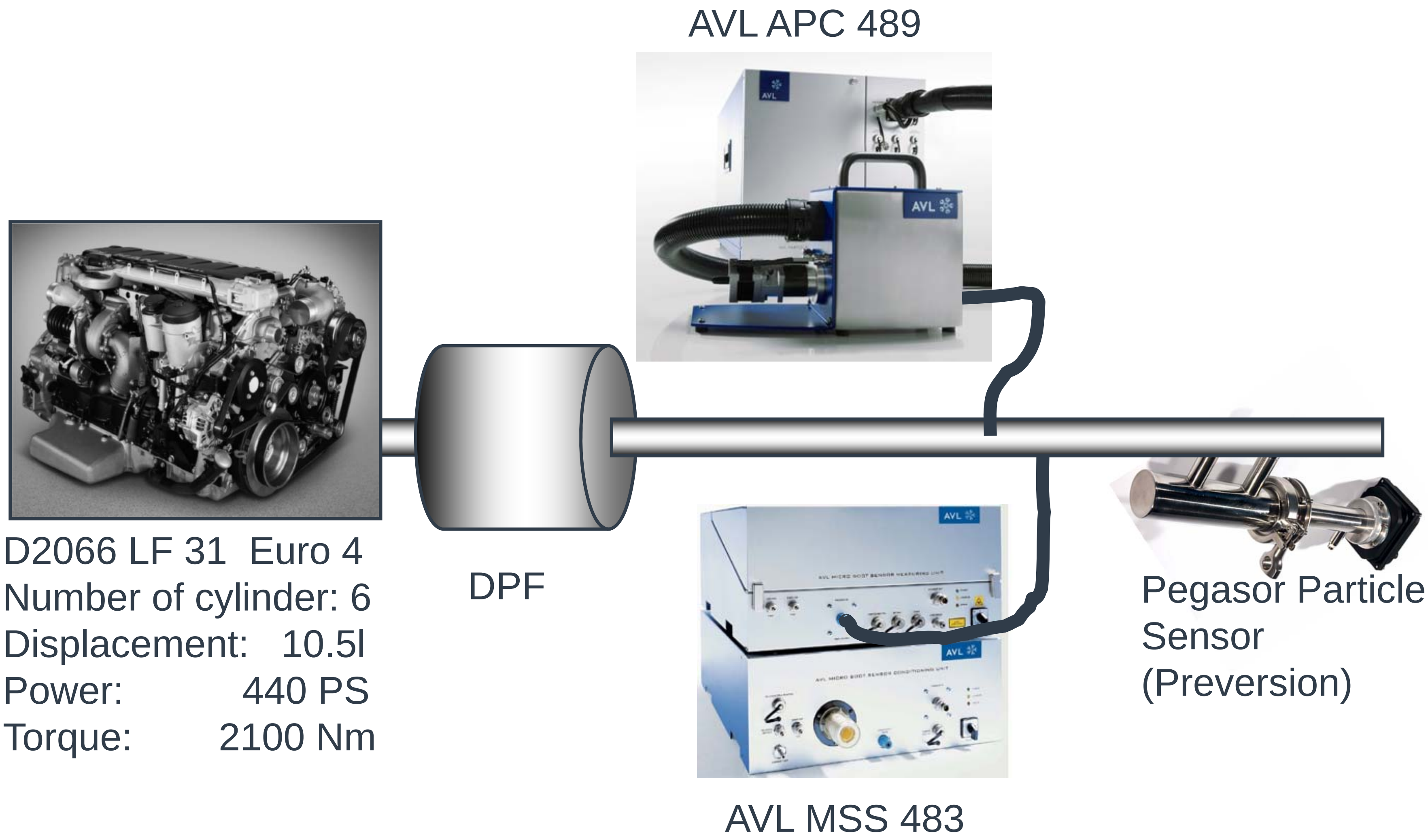


Main Features

- Compact design, installed directly to the tailpipe
- Particles are not collected
- Sensitive parts protected from exhaust flow => Low maintenance
- High resolution and sensitivity (10 Hz, 0.3sec Response Time)

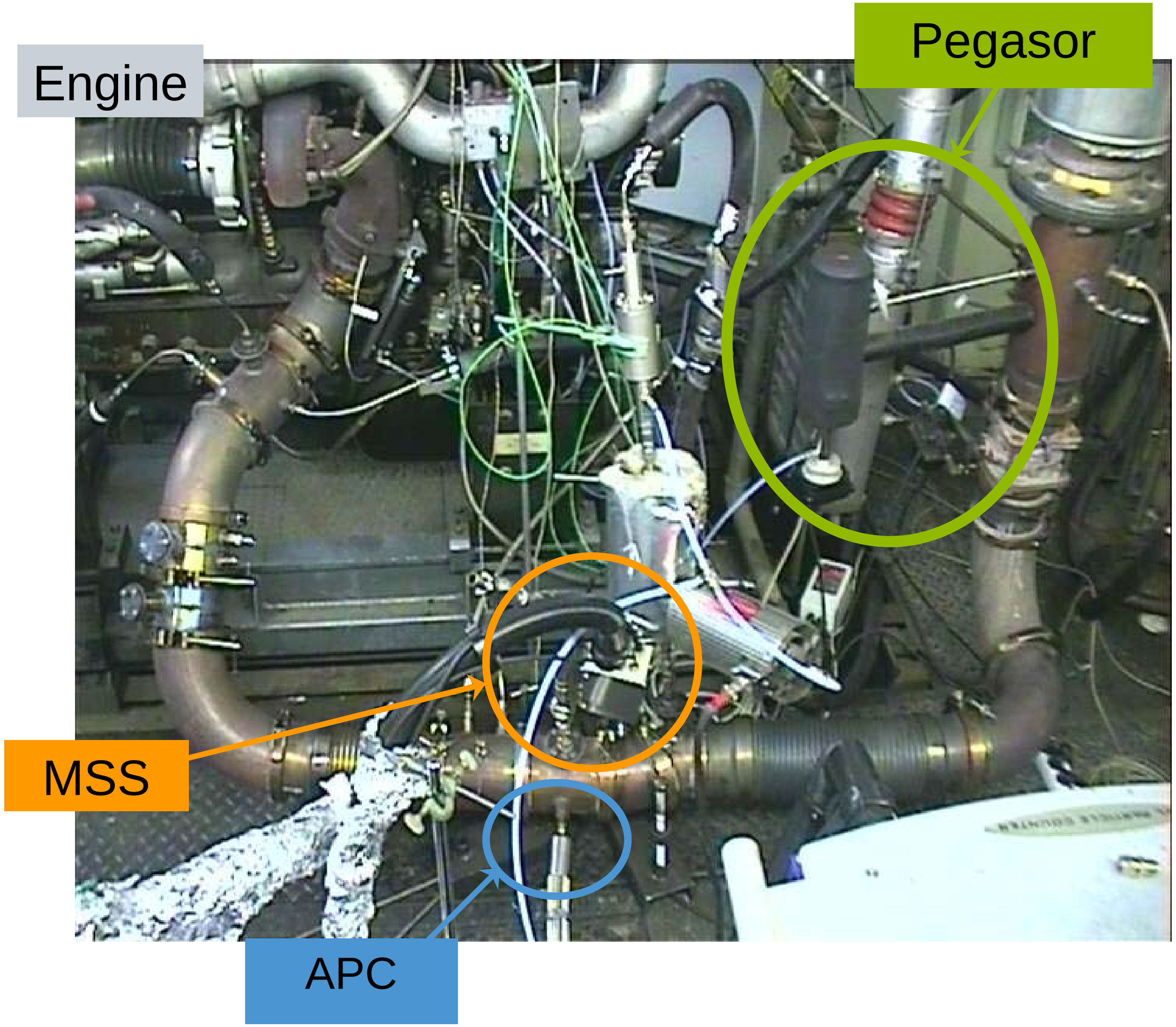
Agenda

3 Experimental Setup (1/3)
(Schematic Overview)



Experimental Setup (2/3)

(Test cell)



Experimental Setup (3/3)
(Test programme)

Investigation topics:

Influence of dilution air pressure on the PPS signal

Signal correlation of PPS vs APC and MSS in stationary test cycle (ESC)

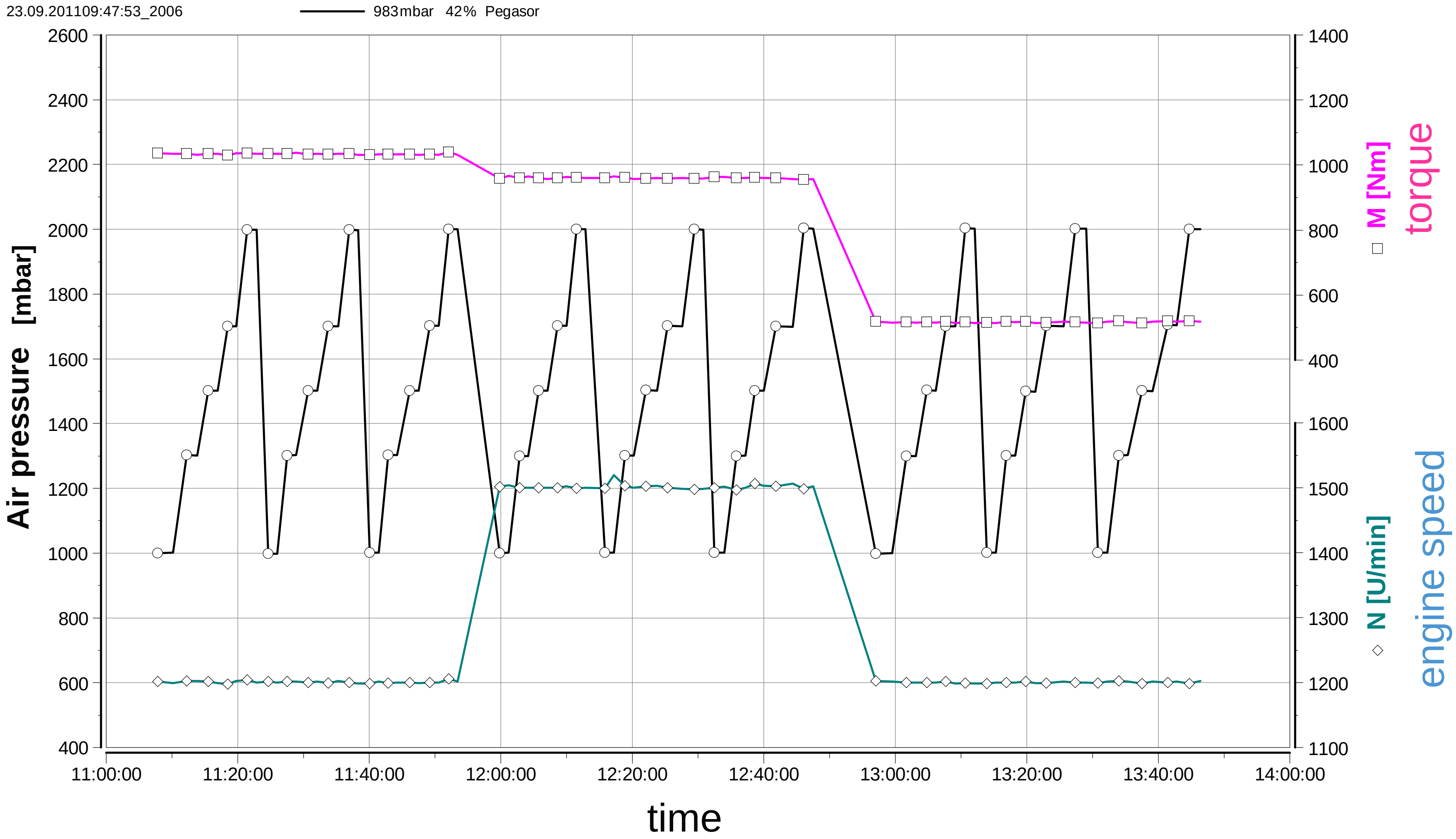
Signal correlation of PPS vs APC and MSS in transient test cycle (ETC)

Correlation in raw exhaust and after diesel particulate filter

Agenda

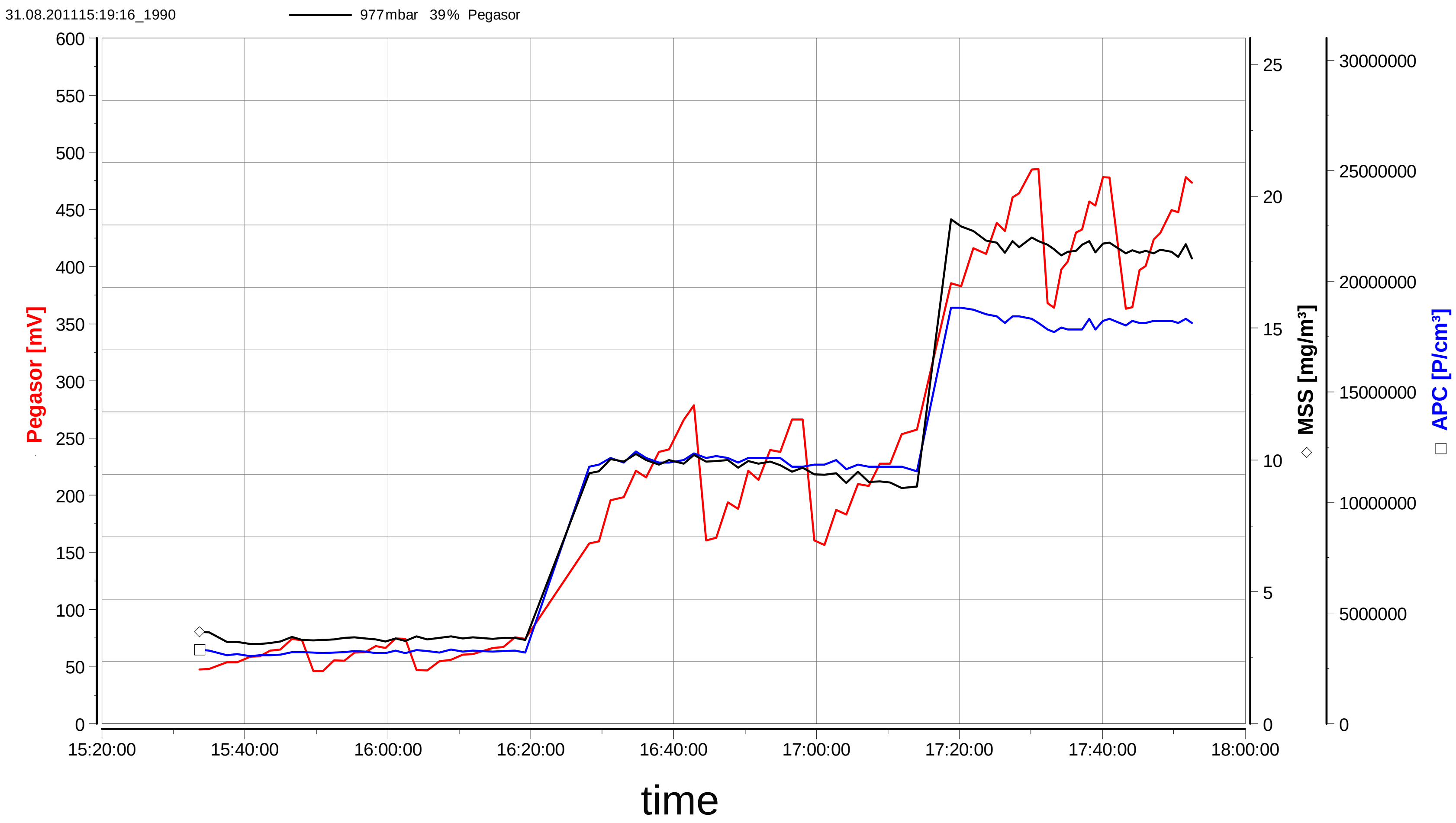
4 Influence of dilution air pressure (1/4)

(Test programme)

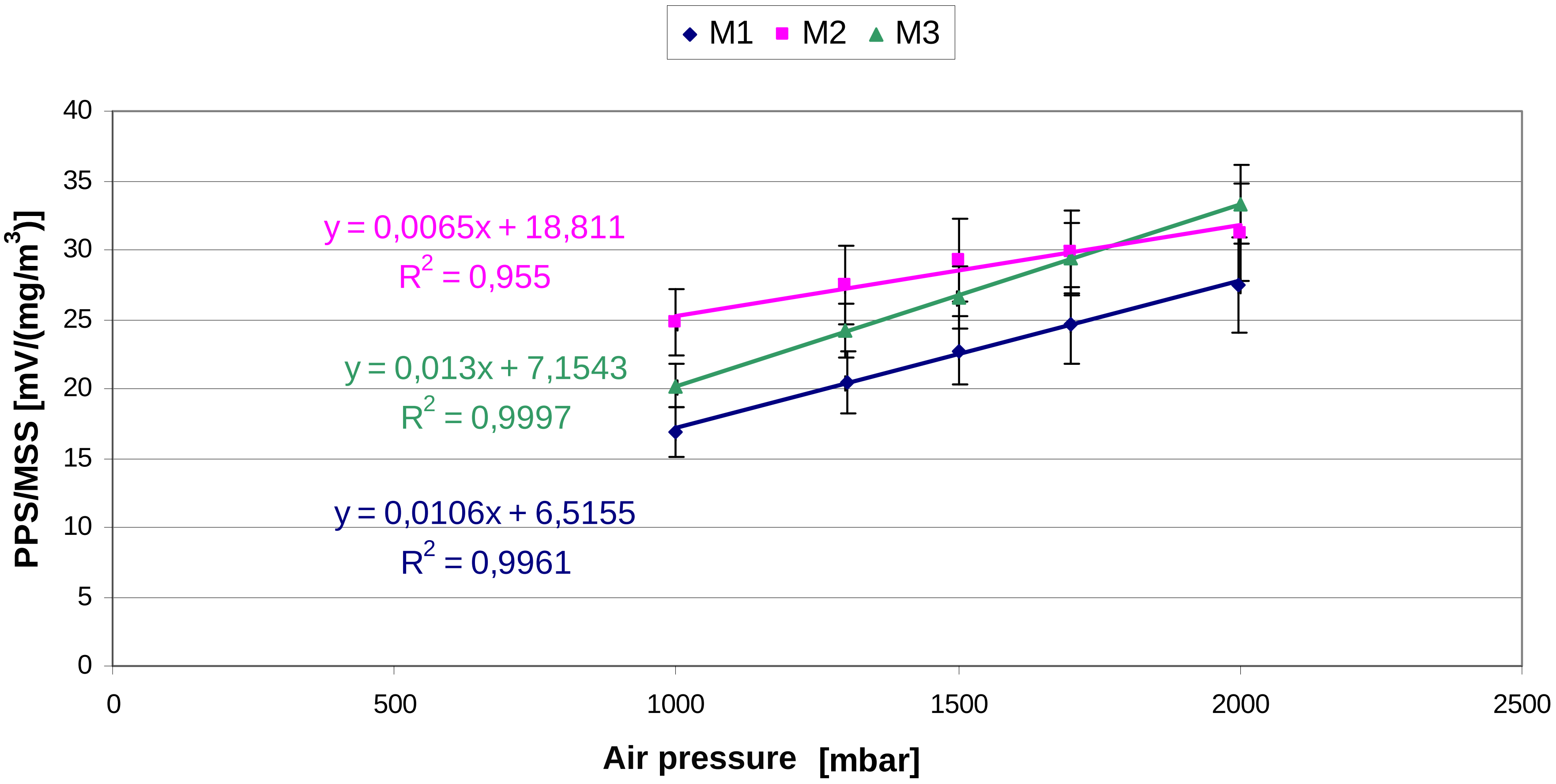


4 Influence of dilution air pressure (2/4)

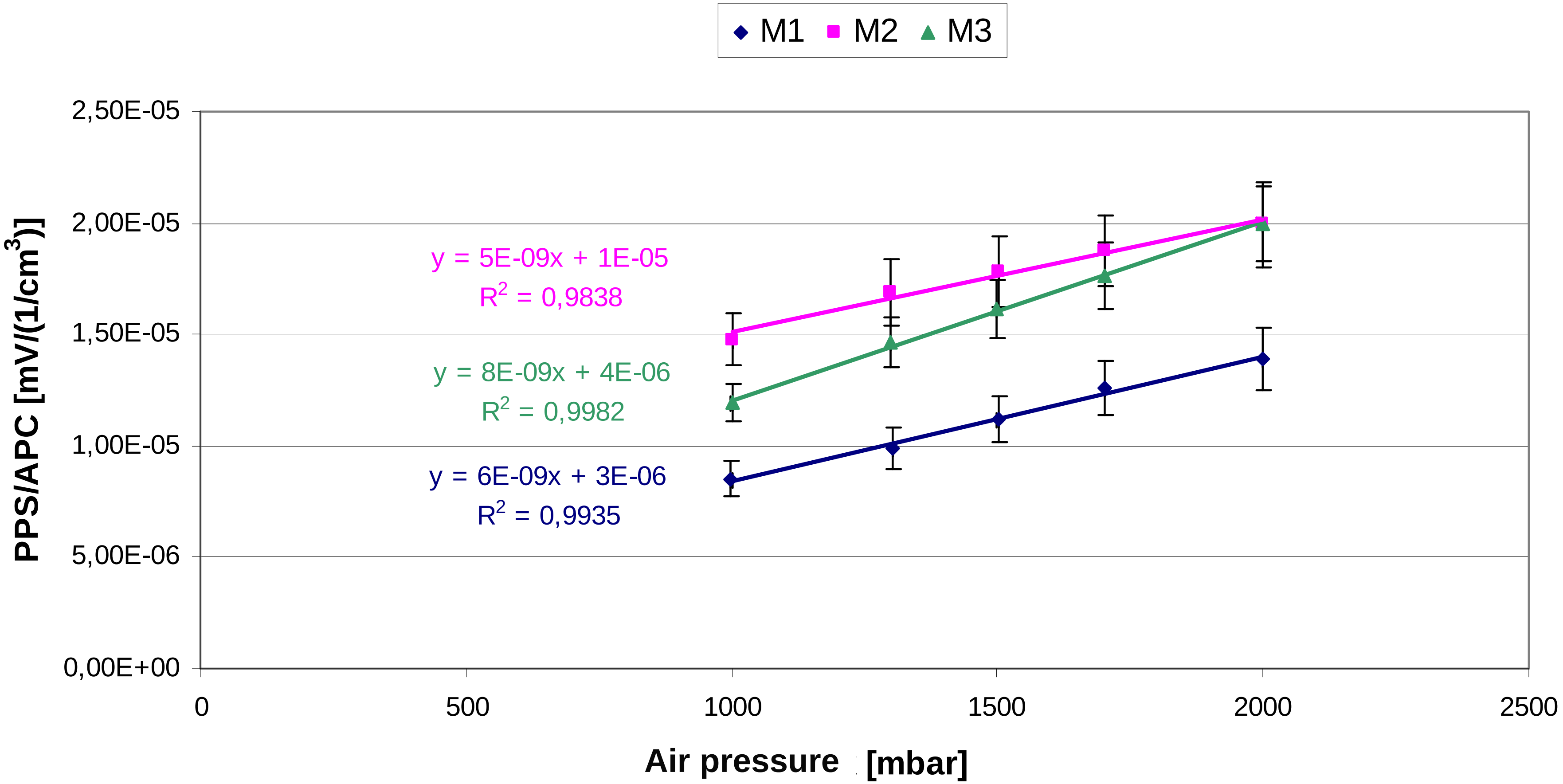
(Signal sequence)



4 Influence of dilution air pressure (3/4)
(PPS vs. MSS)

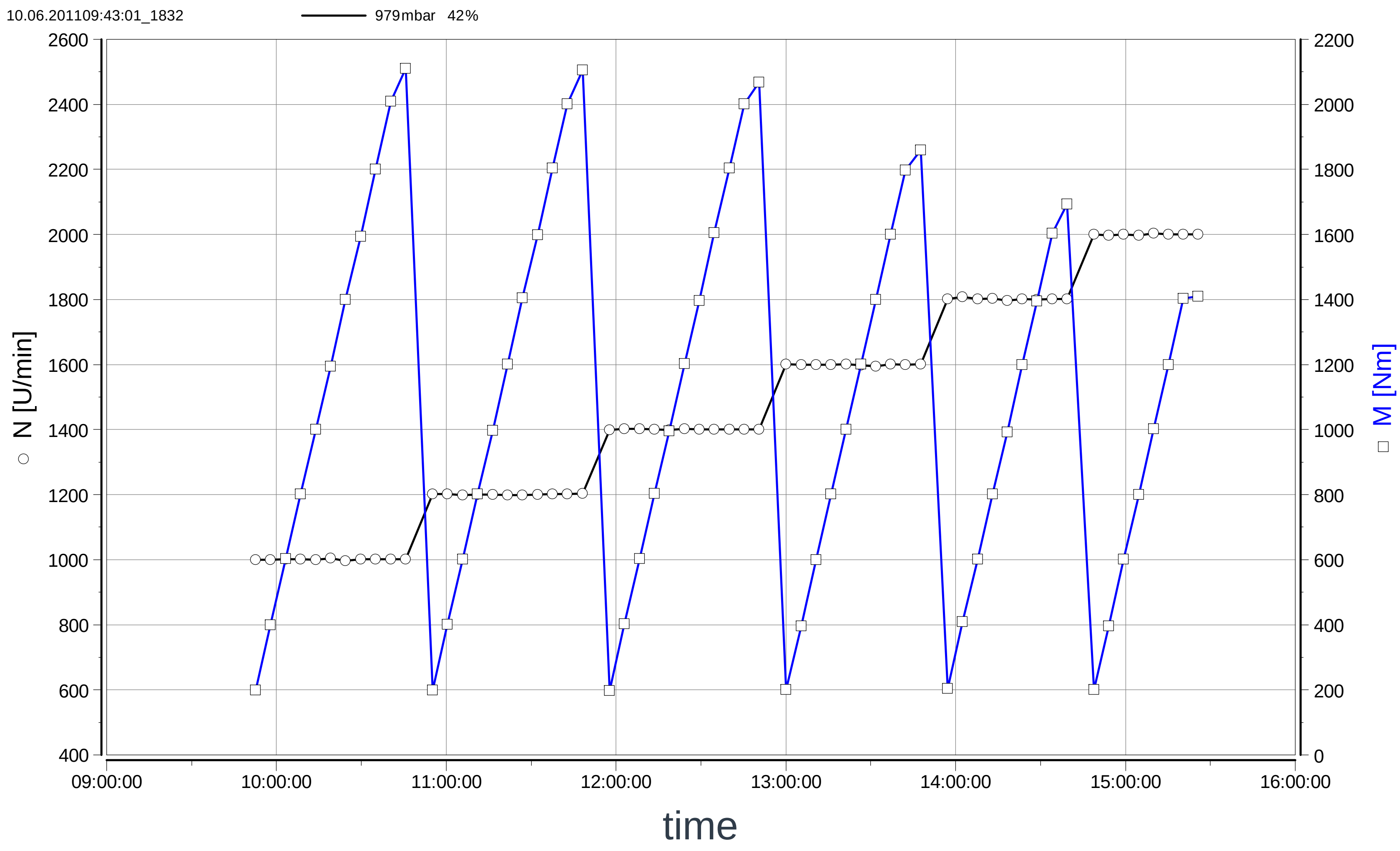


4 Influence of dilution air pressure (4/4)
(PPS vs. APC)



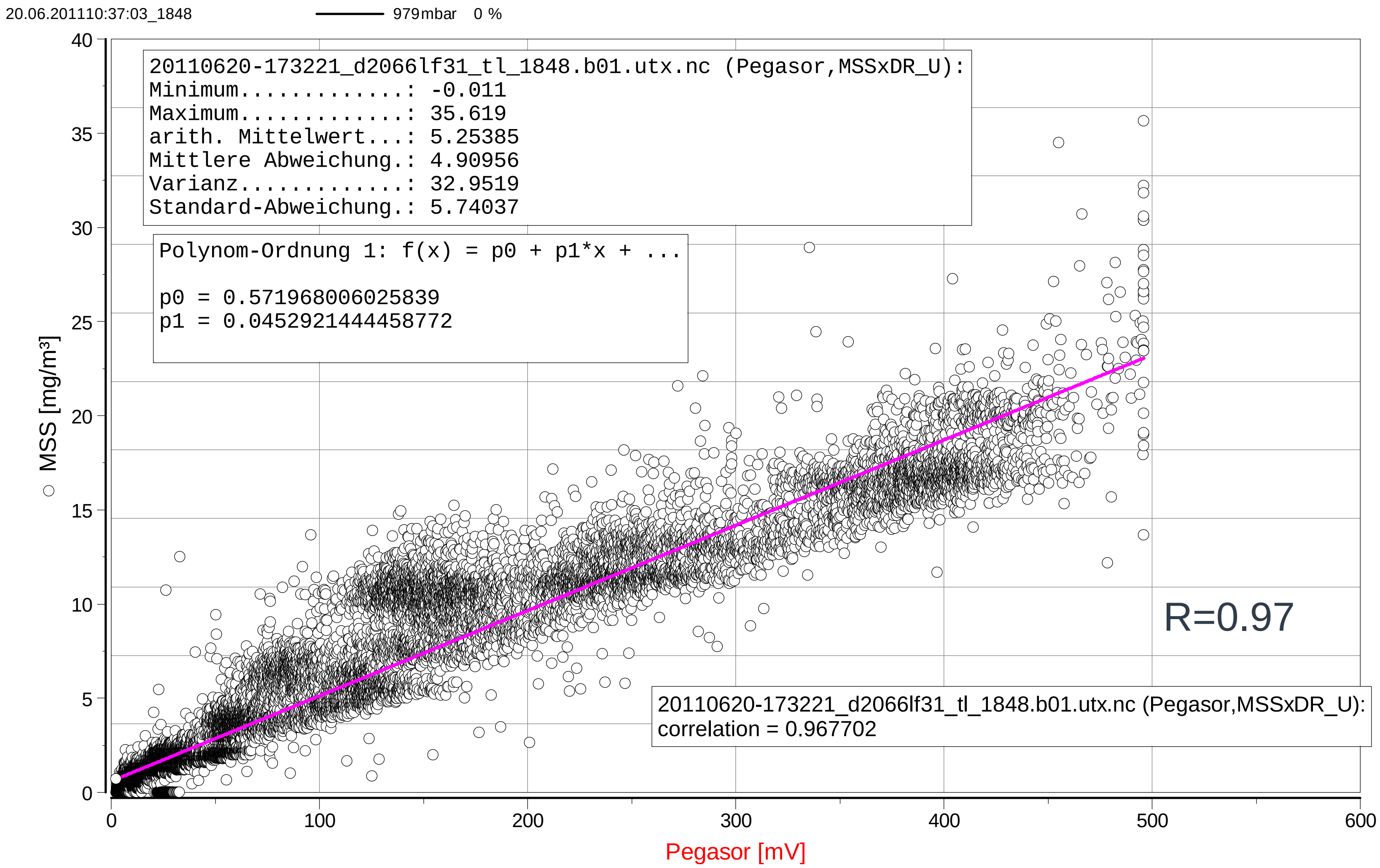
Agenda

5 Correlation Stationary tests (1/7)
(Test programme)

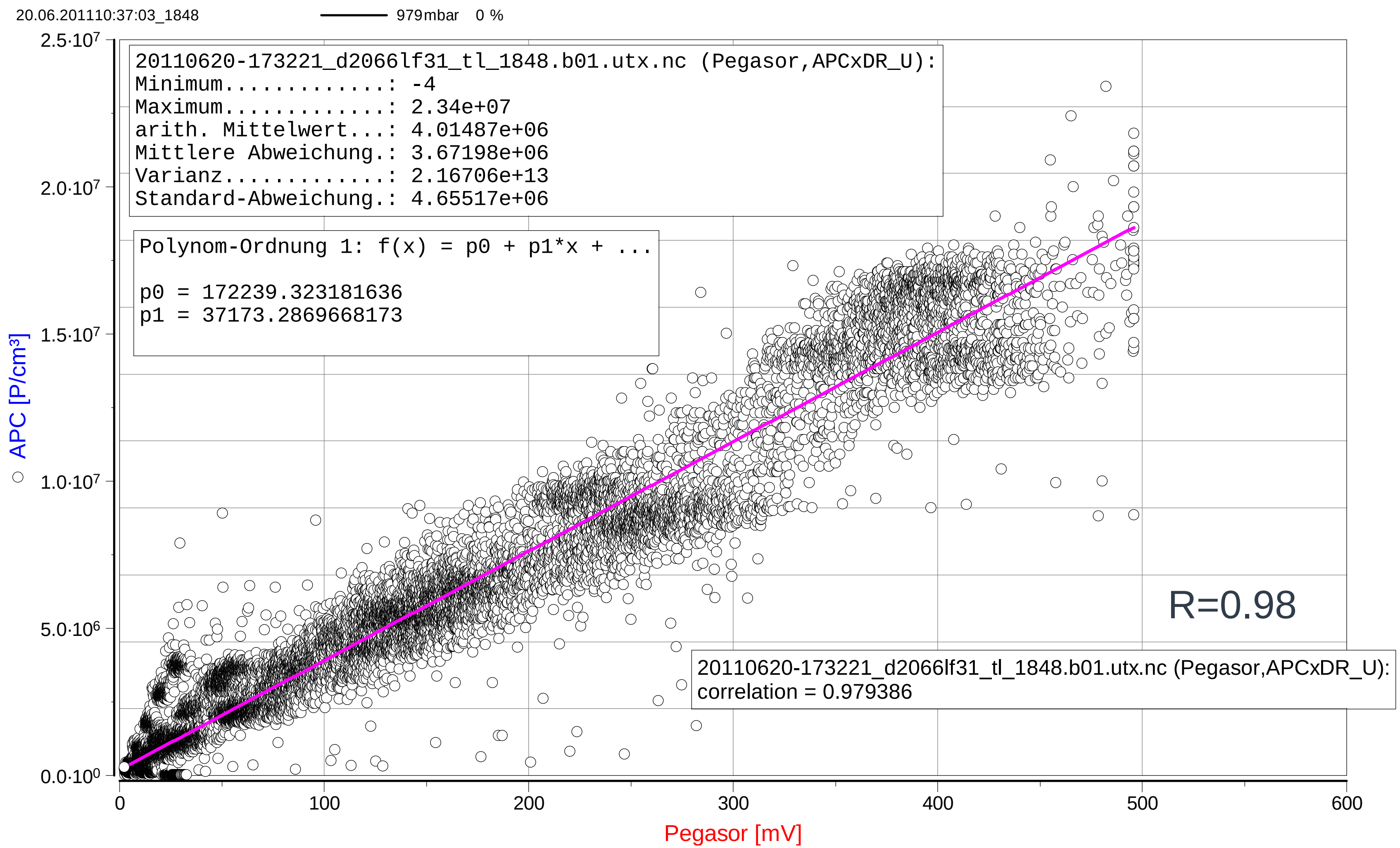


5 Correlation Stationary tests (2/7)

(PPS vs. MSS raw exhaust)

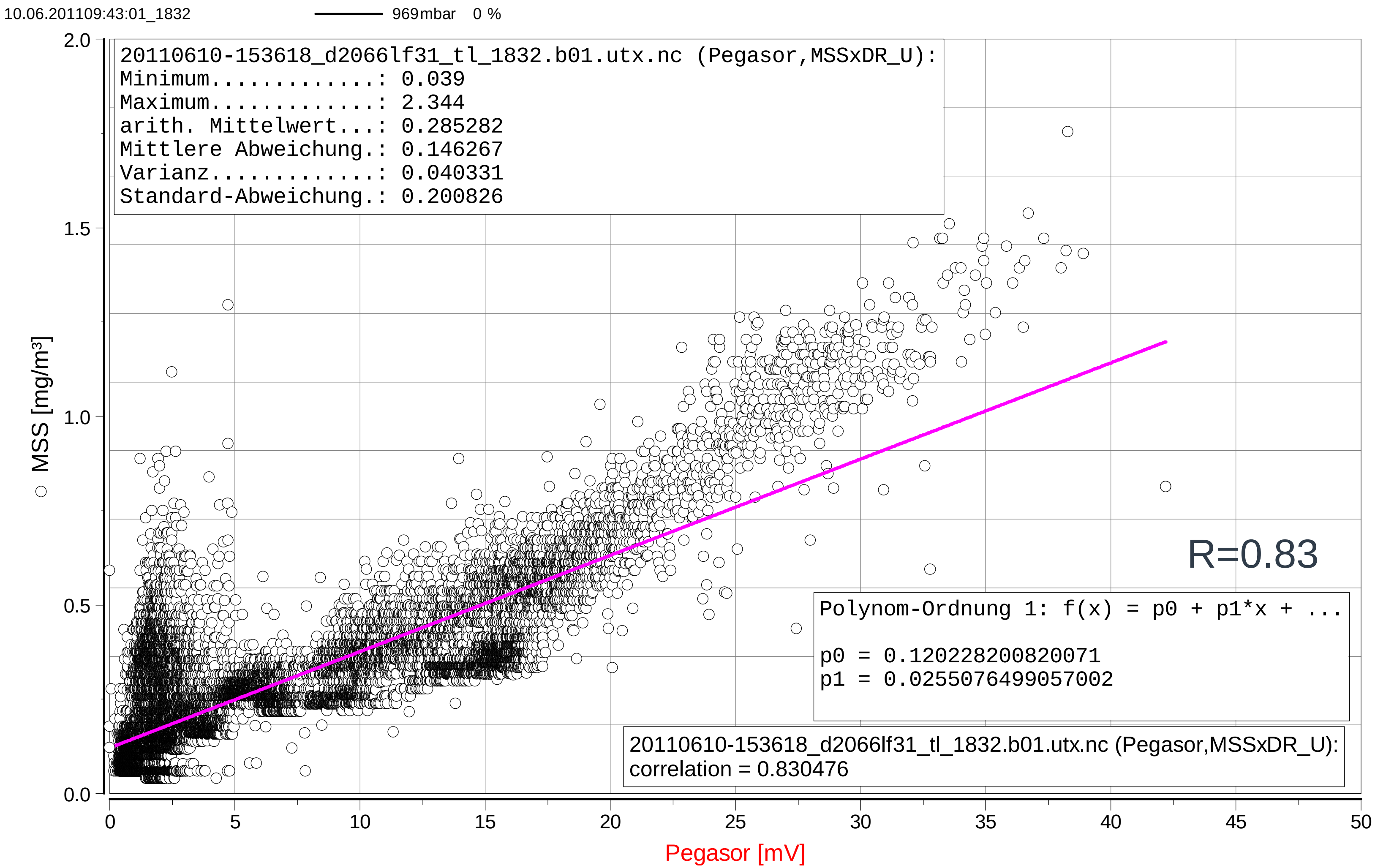


5 Correlation Stationary tests (3/7)
(PPS vs. APC raw exhaust)

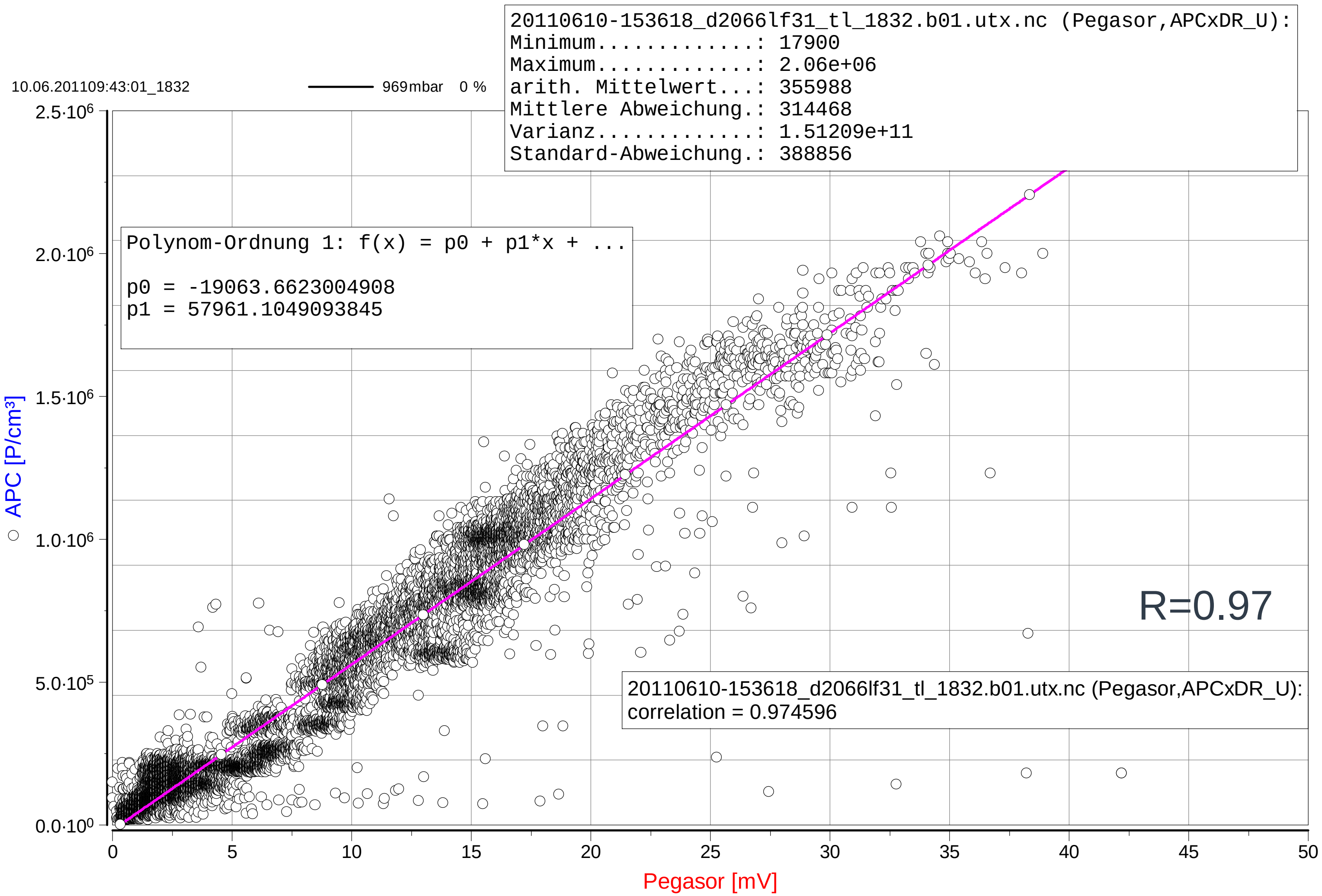


5 Correlation Stationary tests (4/7)

(PPS vs. MSS post DPF)

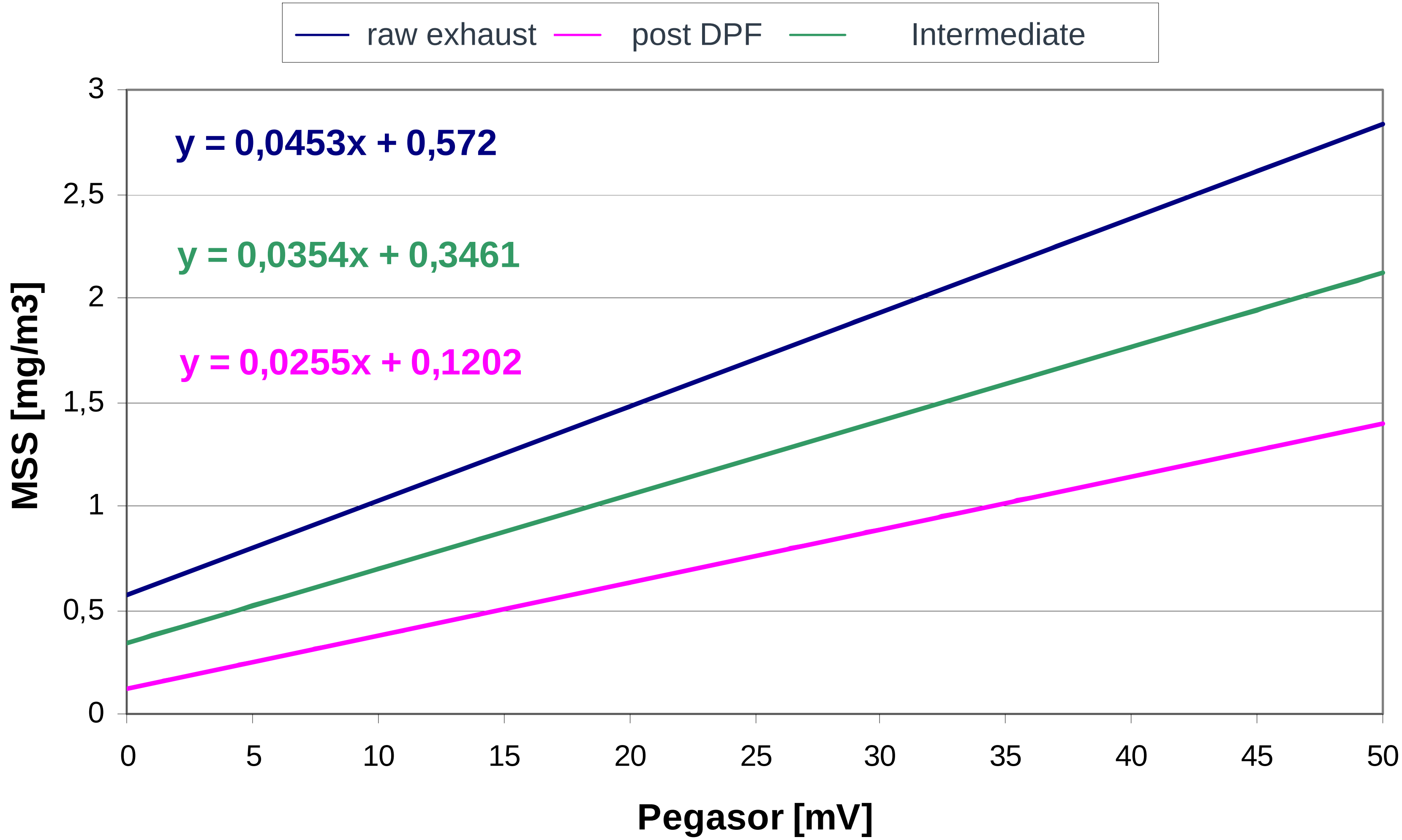


5 Correlation Stationary tests (5/7)
(PPS vs. APC post DPF)



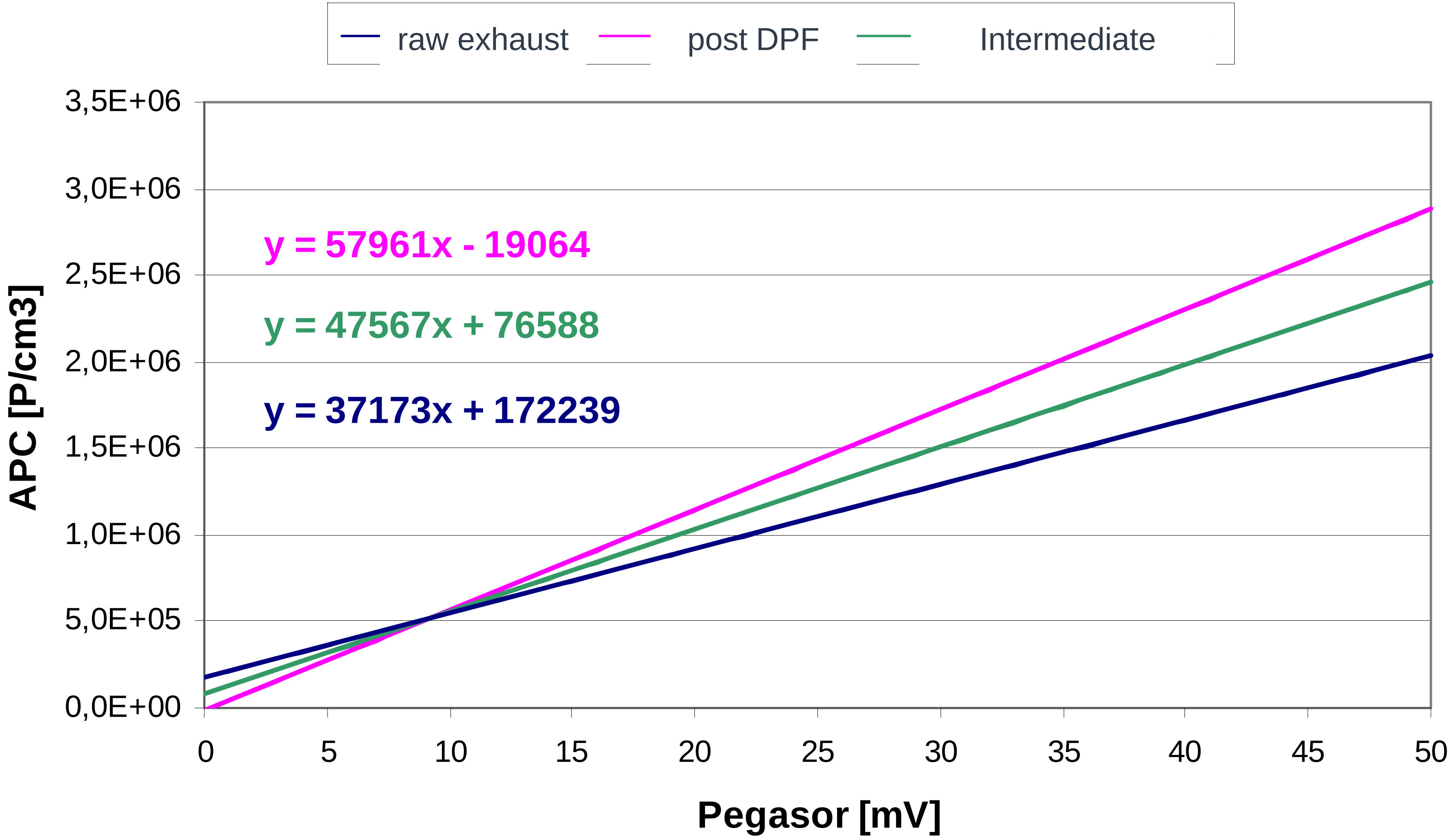
5 Correlation Stationary tests (6/7)

(PPS vs. MSS)



5 Correlation Stationary tests (7/7)

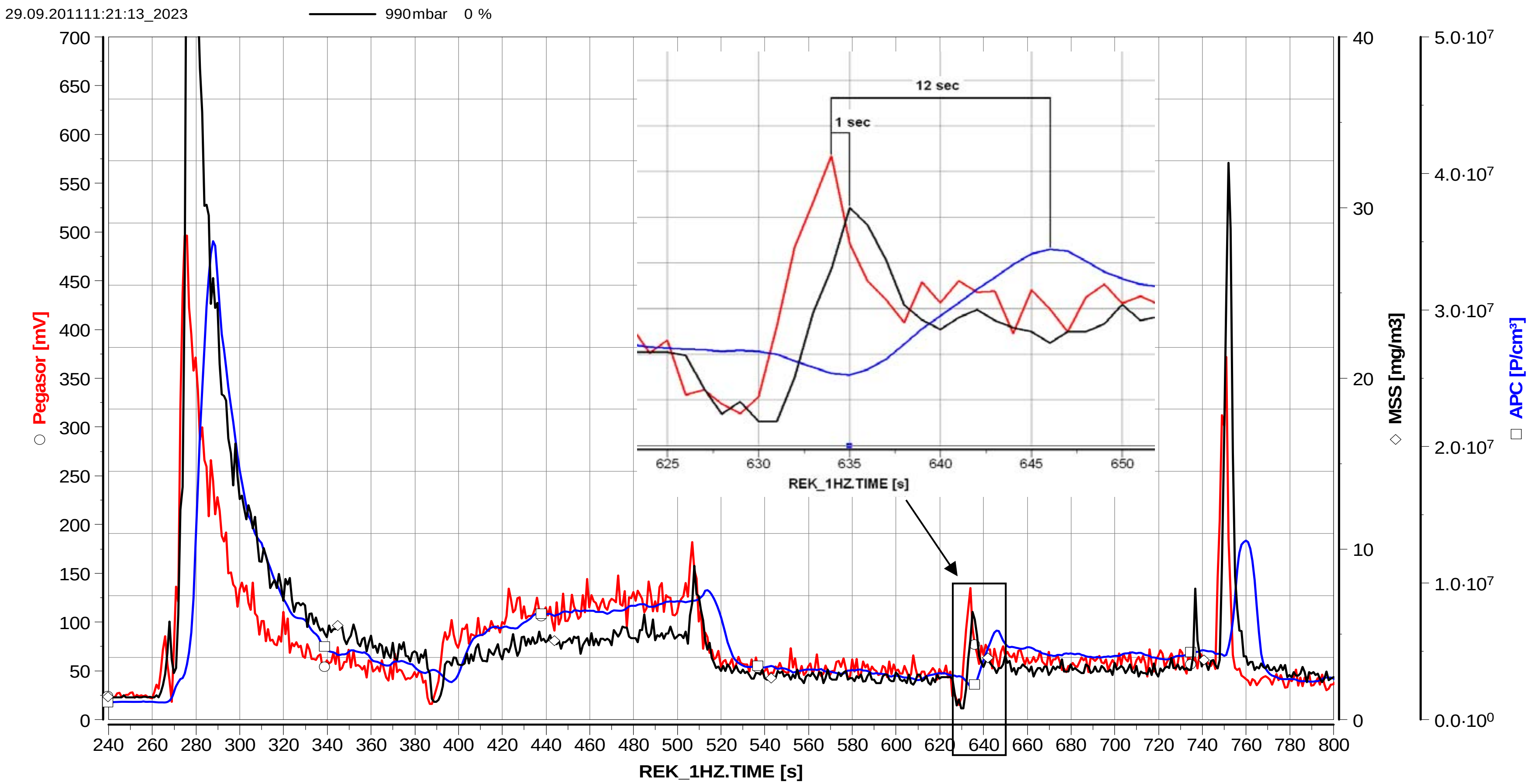
(PPS vs. APC)



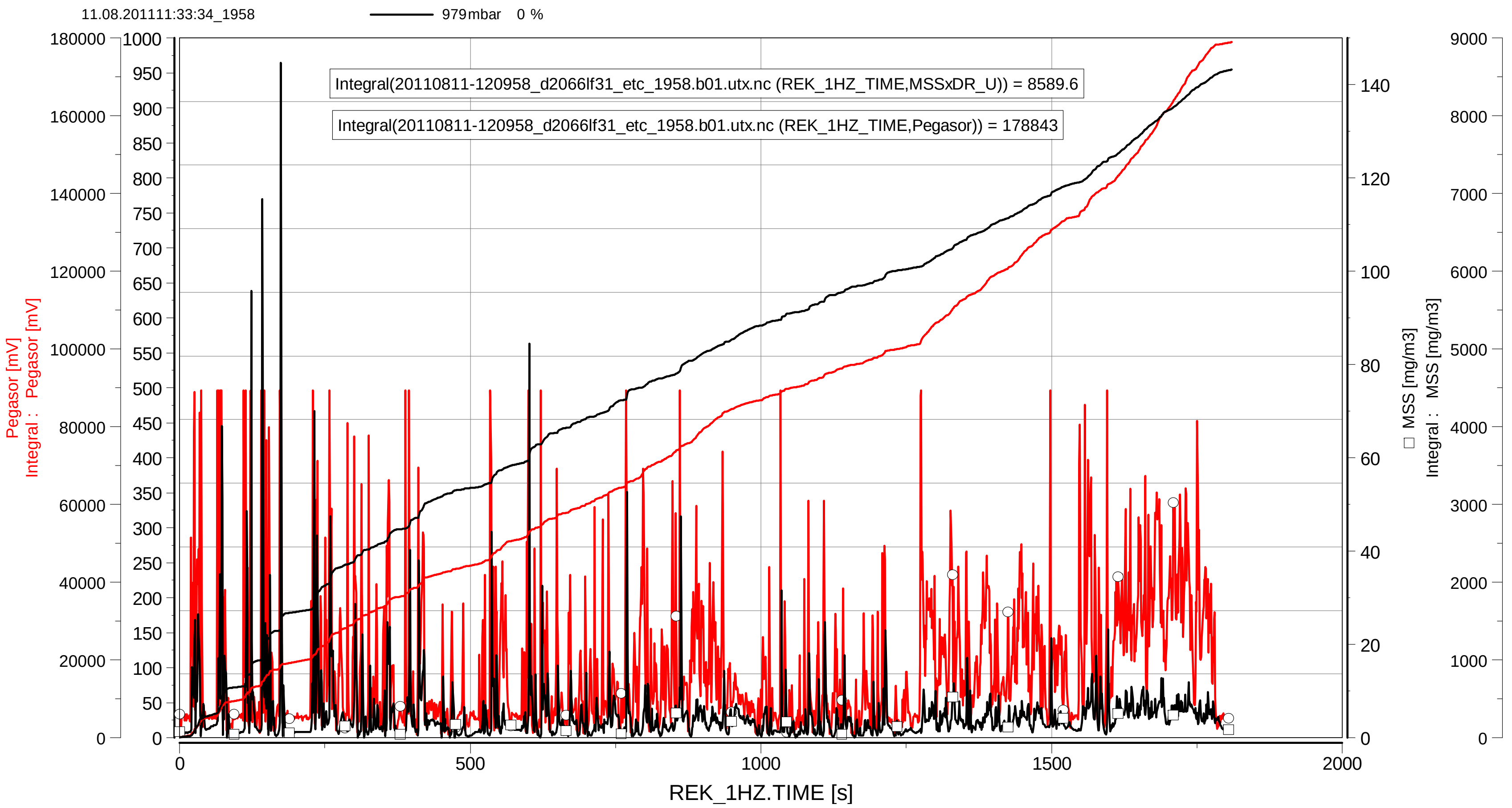
Agenda

6 Transient test signal (1/5)

(PPS vs. MSS raw exhaust)

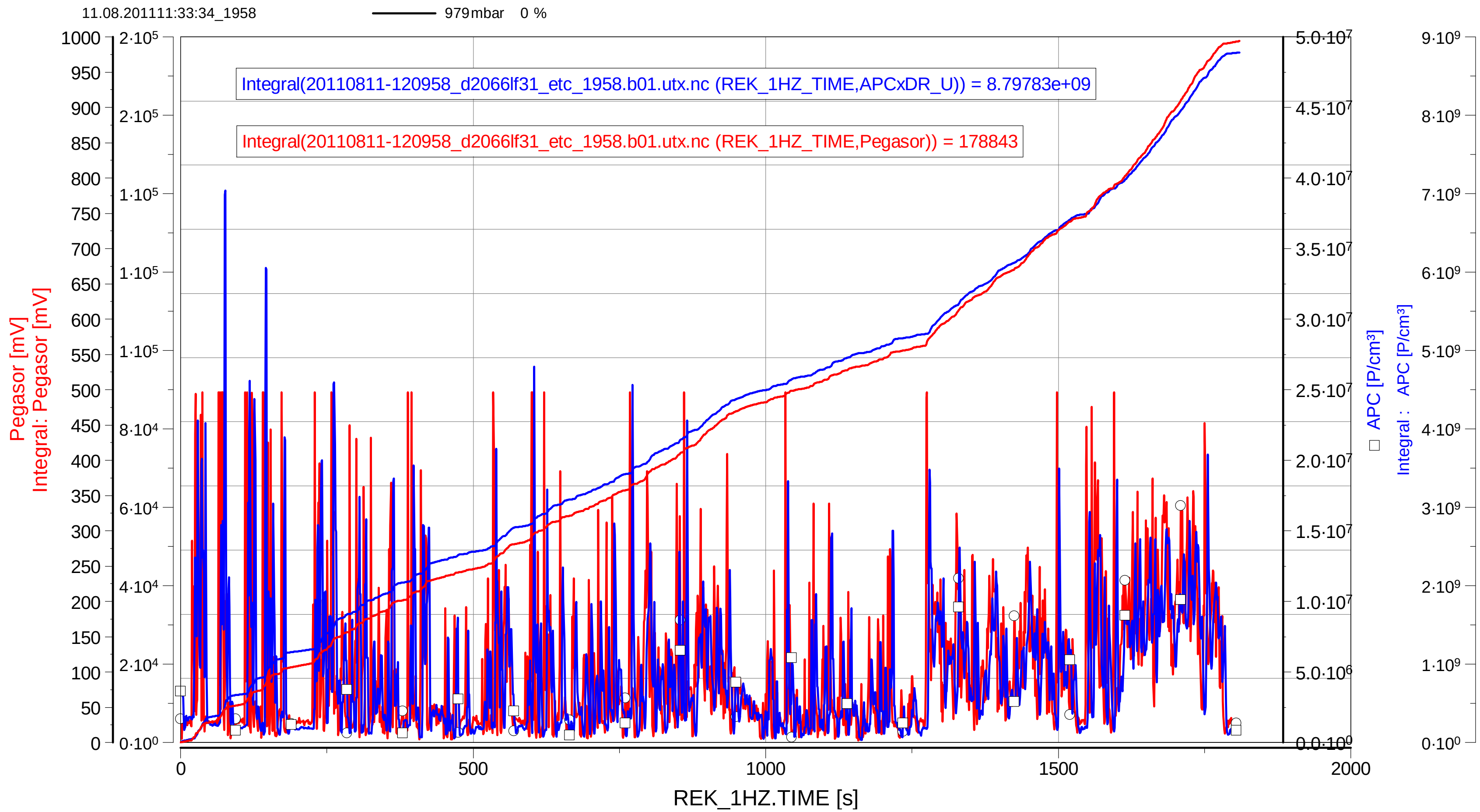


6 Correlation Transient tests (2/5)
(PPS vs. MSS raw exhaust)

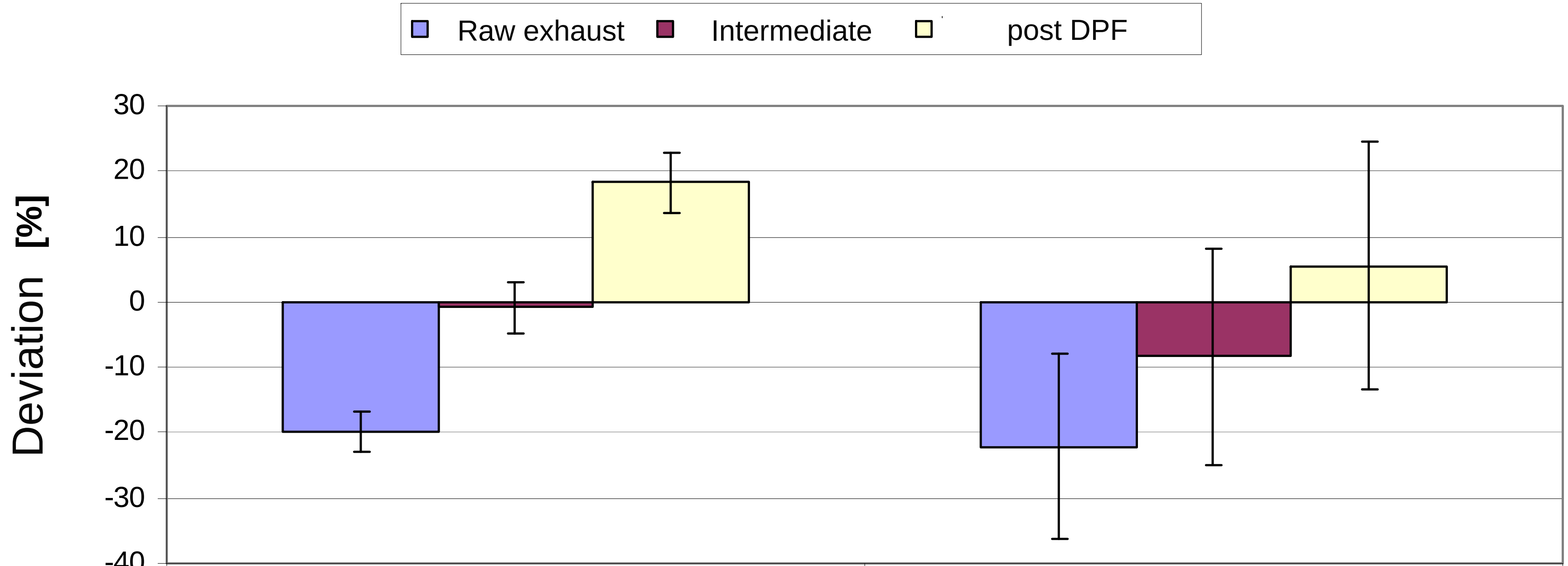


6 Correlation Transient tests (3/5)

(PPS vs. APC)



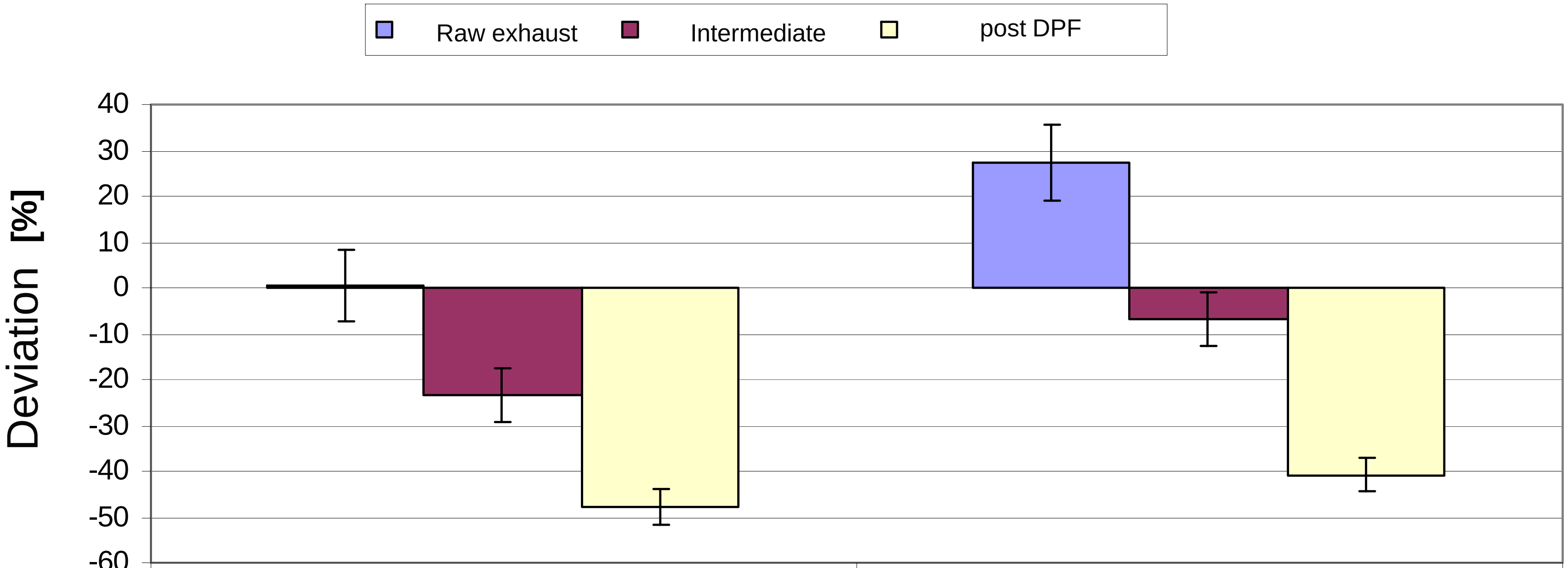
6 Correlation Transient tests (4/5)
(PPS vs. APC average 6 ETC)



	Raw exhaust measurement	Measurement after DPF
Raw exhaust	-19,83	-22,18
Intermediate	-0,80	-8,35
post DPF	18,22	5,49

6 Correlation Transient tests (5/5)

(PPS vs. MSS average of 6 ETC)



	Raw exhaust measurement	Measurement after DPF
Raw exhaust	0,65	27,19
Intermediate	-23,61	-6,80
post DPF	-47,86	-40,79

7 Conclusion

Pegasor Particle Sensor (PPS) was tested under heavy duty real world conditions.

In transient tests the sensor proofed a fast response time

With constant dilution air pressure results were found reproducible

(For traceability reasons an additional pressure recording is recommended)

Under partial load stationary conditions good correlation were found for raw exhaust measurements MSS- (>96%) and APC-Signal (>98%) and for measurements after DPF MSS- (>83%) and APC-Signal (>97%)

The correlation equation found under partial load condition were applied on ESC and ETC. The calculated results lead to deviations of less than 10 % compared with reference analytics.

Time for Questions

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