Photoacoustic Spectroscopy using a Quantum Cascade Laser

Optical Gas Sensing Swissphotonics–Workshop
Dübendorf 15.01.15

Christoph Klotz

ECO PHYSICS

Overview

- ECO PHYSICS AG
- Photoacoustic Spectroscopy
- Quantum Cascade Laser (QCL)
- Analyser PAS 87
- Applications

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Headquarter
Dürnten, CH

Distribution
partners
around the
globe

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- Enviromental

- Industrial

- Automotive

- Semiconductor

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- Medical

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- CLD

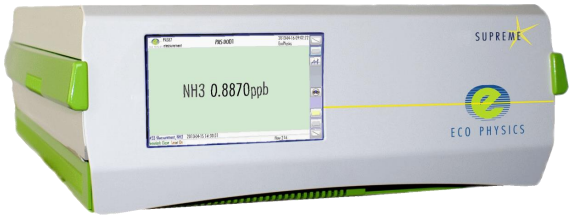
Chemiluminescence

$$NO + O_3 \rightarrow NO_2^* + O_2$$

$$NO_2^* \rightarrow NO_2 + h\nu$$

- PAS

Photoacoustic Spectroscopy



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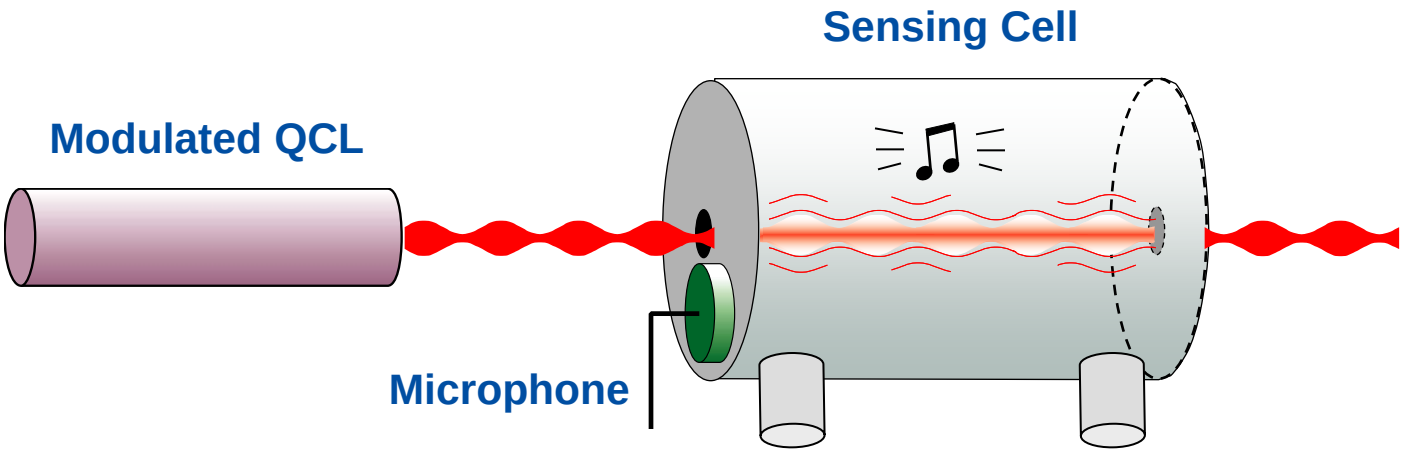
Photoacoustic Spectroscopy (I)



Signal: $S \propto P_{Laser} \cdot c\,NH_3$

- Wavelength – Absorption band of molecule.
- Local temperature rise results in pressure increase.
- Light source modulation → Pressure variations → Sound.
- Signal detection with microphone.

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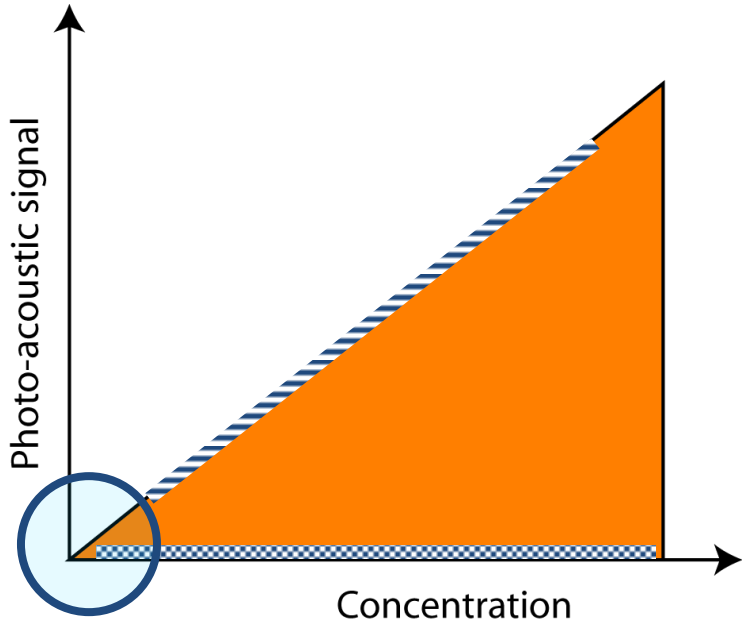
Photoacoustic Spectroscopy (II)

- Advantages:
  - Zero-Baseline
  - Linearity
  - Dynamic Range



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Quantum Cascade Laser (QCL)

- Repeated stack of semiconductor heterostructures.
- Layer thickness of a few nm allows a compact design.
- Tunneling to the next structural period allows repetition of intersubband transitions and emission of photons.

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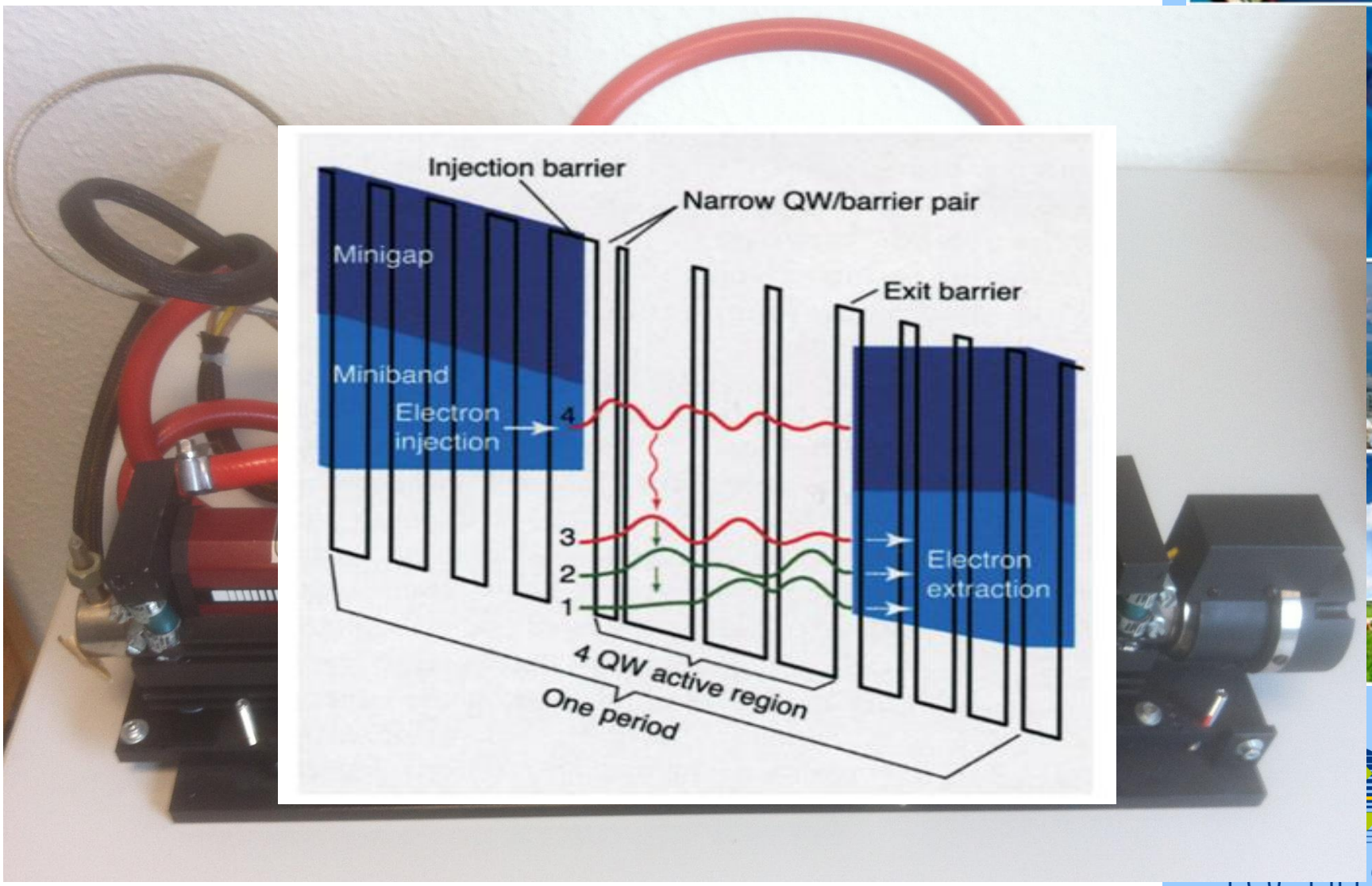
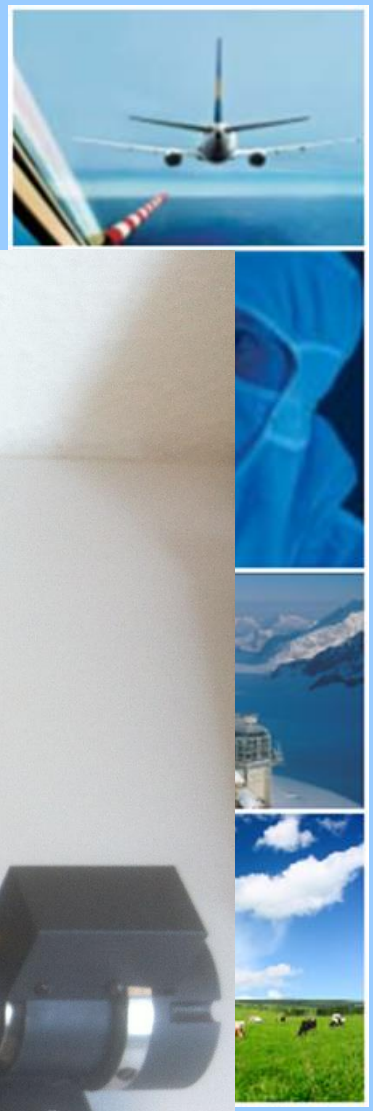
Quantum Cascade Laser (QCL)





Advantages

- Monochromatic radiation → high detection sensitivity
- Small dimensions → compact design
- No external cooling required → compact design & low operating costs
- Long maintenance intervals → low operating costs
- High efficiency due to cascade effect → low operating costs

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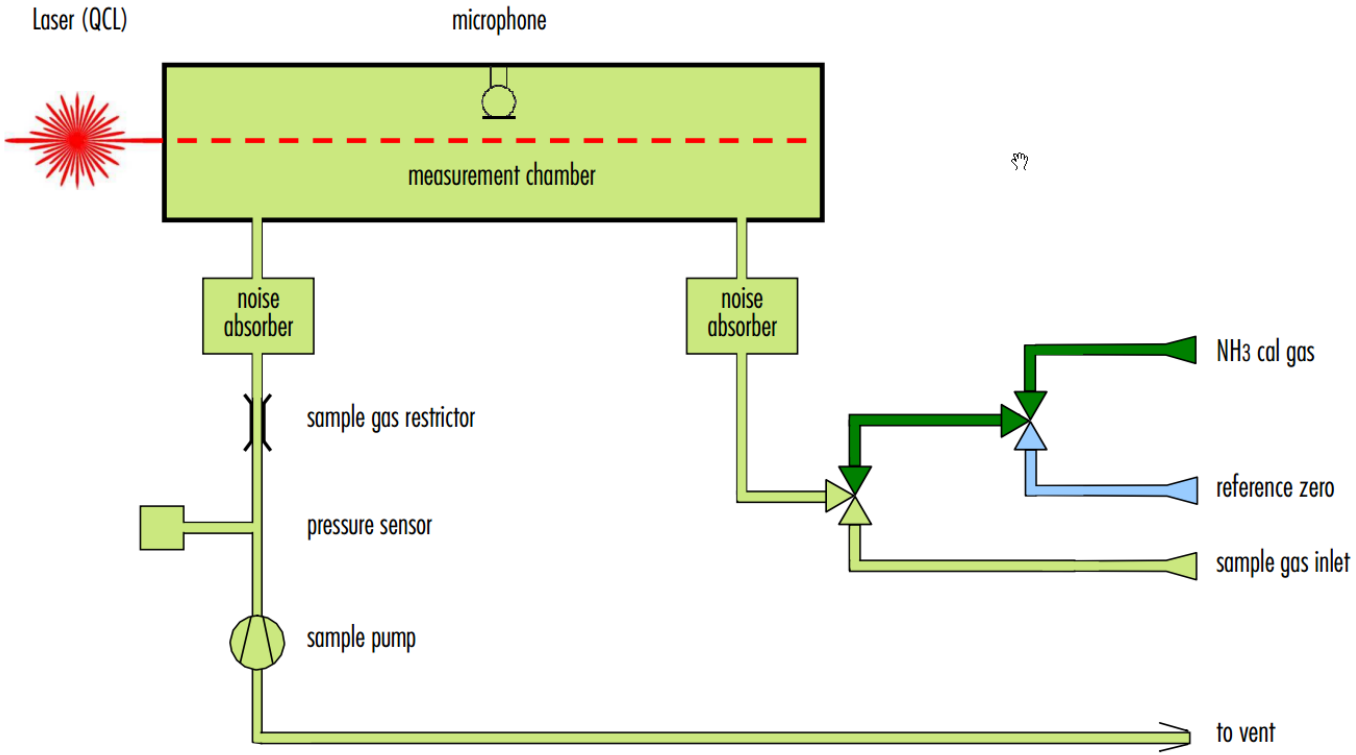
PAS 87
SUPREME
ECO PHYSICS
NH3 0.8870ppb
PAS.0001


Laser (QCL)
microphone
measurement chamber
noise absorber
noise absorber
sample gas restrictor
pressure sensor
sample pump
NH3 cal gas
reference zero
sample gas inlet
to vent

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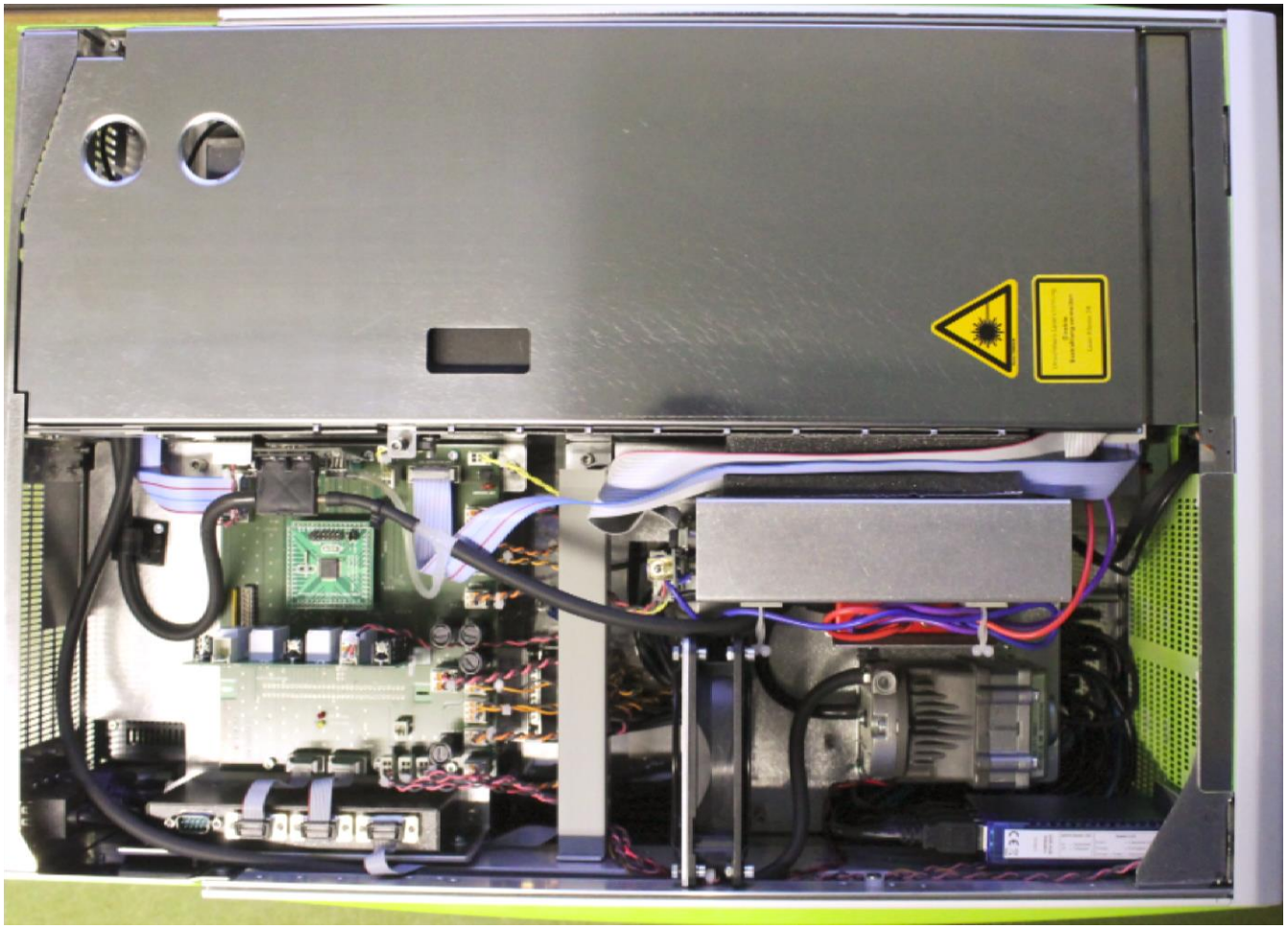
Top View



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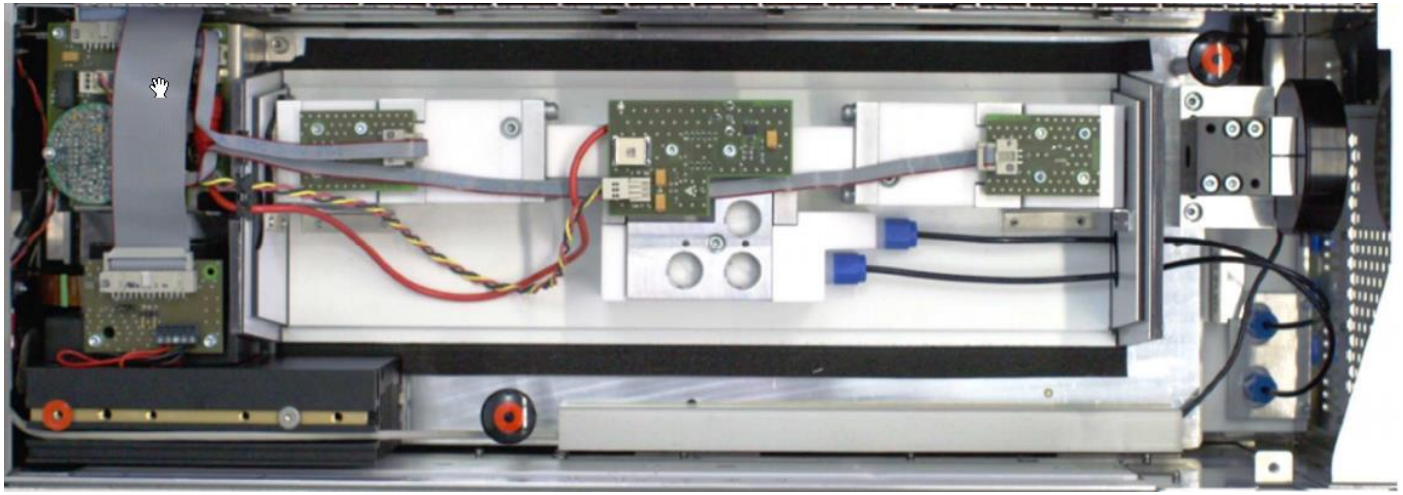
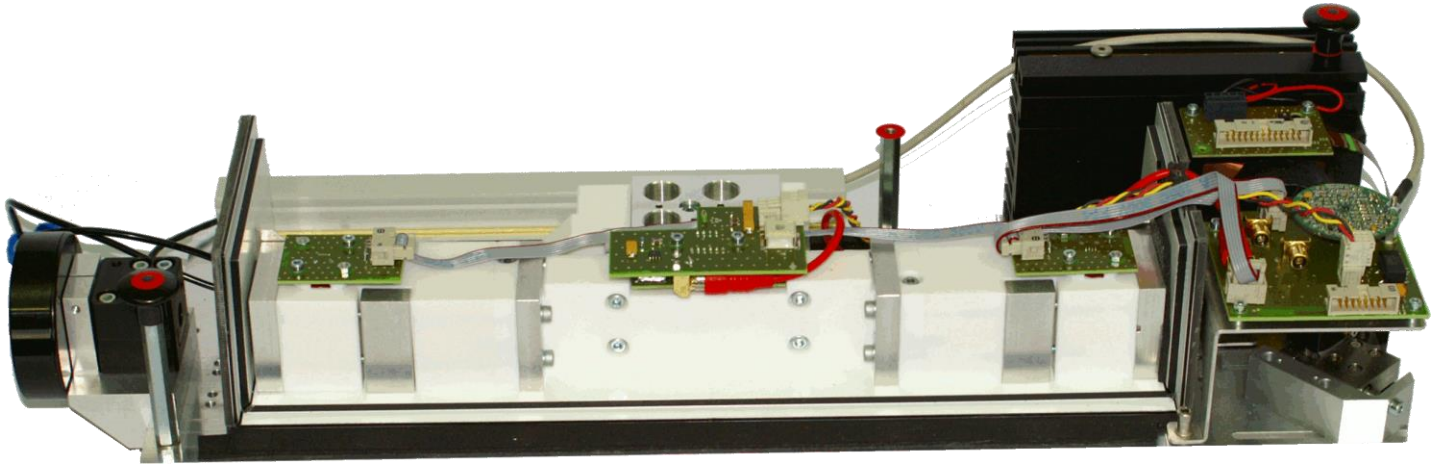
Detector unit





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Applications

- Emission:

  Measurement in a cowshed
- Immission:

  Background monitoring
- Semiconductor:

  Cleanroom monitoring

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Field Test @ Triemenhof

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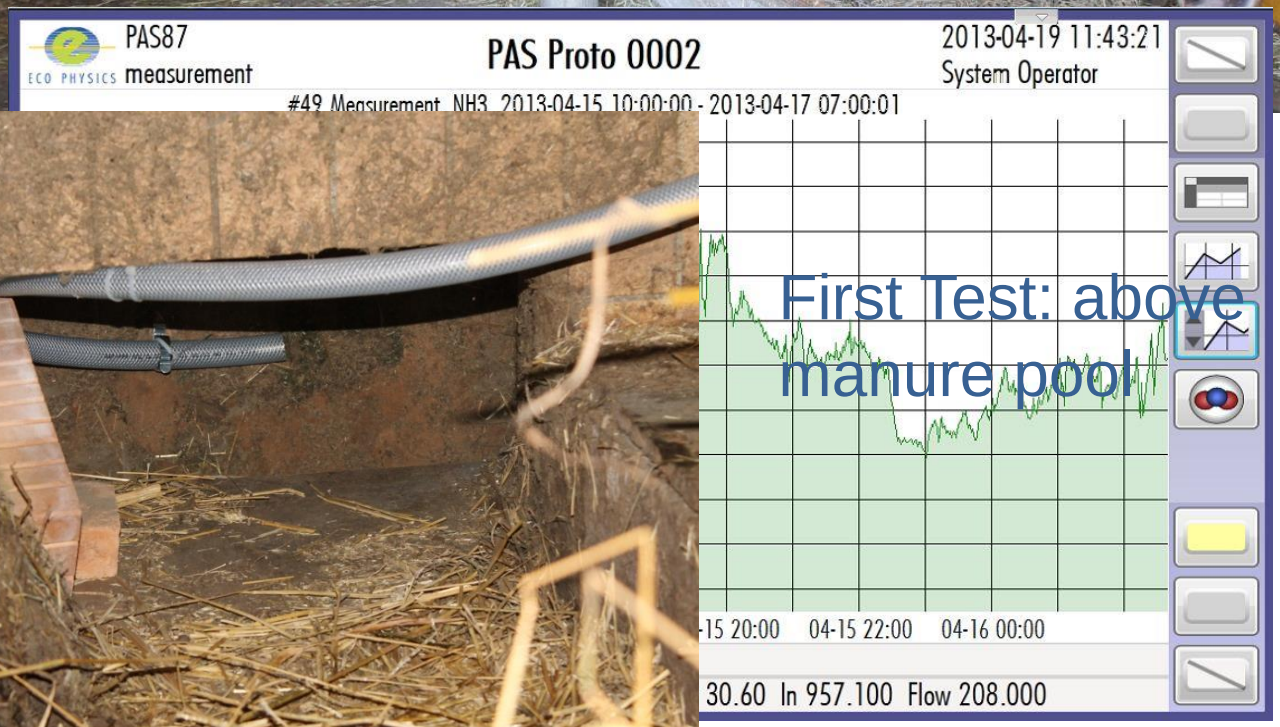

First Test: above manure pool

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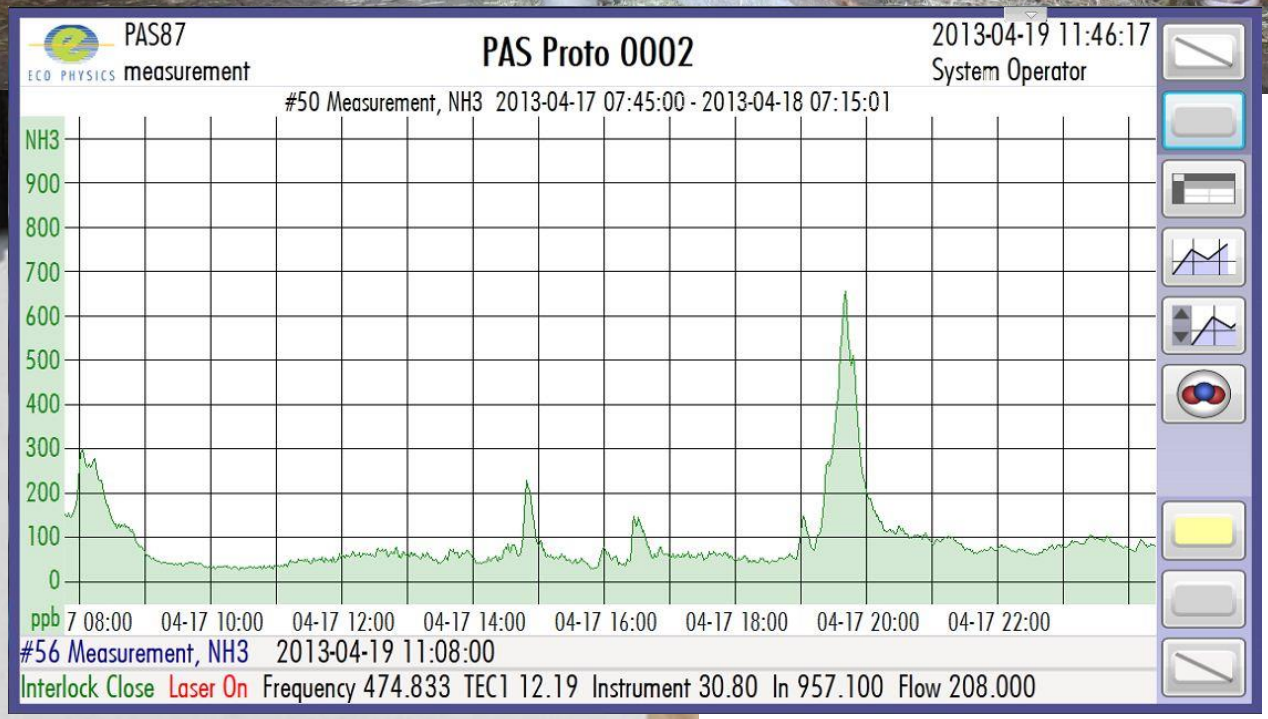
PAS87
ECO PHYSICS measurement
PAS Proto 0002
2013-04-19 11:46:17
System Operator
#50 Measurement, NH3 2013-04-17 07:45:00 - 2013-04-18 07:15:01
NH3
900
800
700
600
500
400
300
200
100
0
ppb
7 08:00
04-17 10:00
04-17 12:00
04-17 14:00
04-17 16:00
04-17 18:00
04-17 20:00
04-17 22:00
#56 Measurement, NH3 2013-04-19 11:08:00
Interlock Close Laser On Frequency 474.833 TEC1 12.19 Instrument 30.80 In 957.100 Flow 208.000

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Second Test: outside the cowshed

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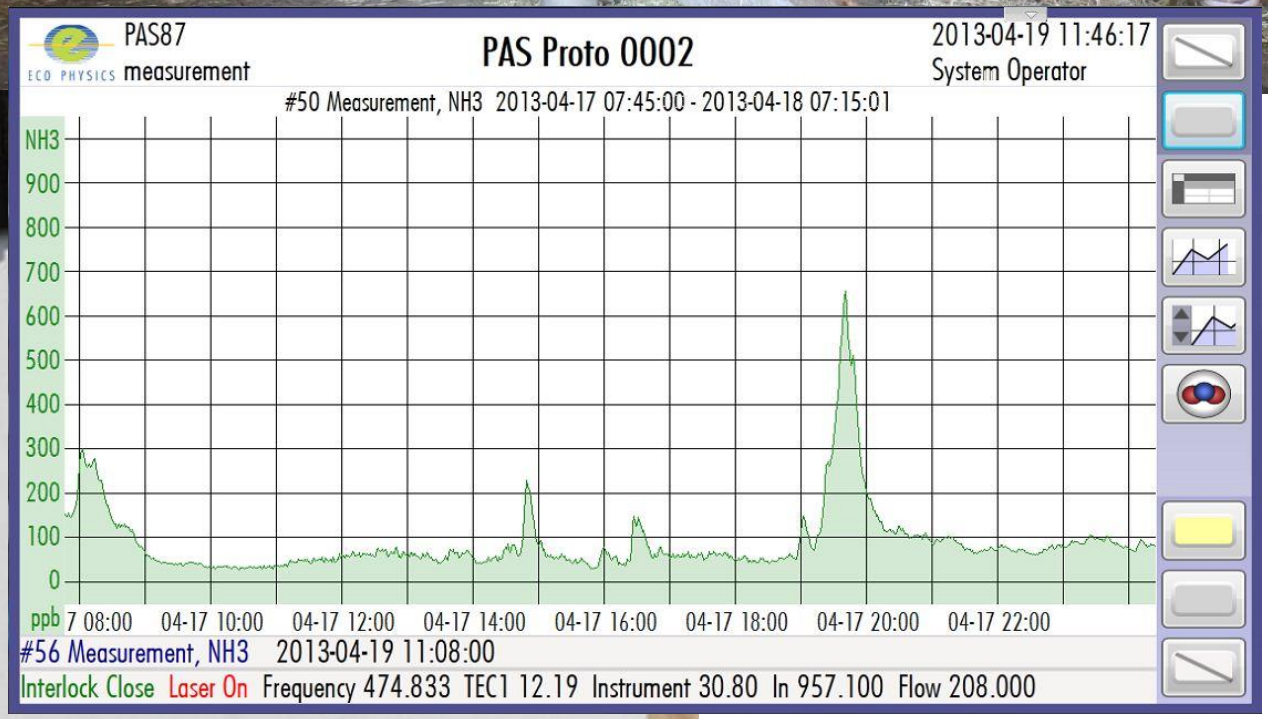
PAS87
ECO PHYSICS measurement
PAS Proto 0002
2013-04-19 11:46:17
System Operator
#50 Measurement, NH3 2013-04-17 07:45:00 - 2013-04-18 07:15:01
NH3
900
800
700
600
500
400
300
200
100
0
ppb
7 08:00
04-17 10:00
04-17 12:00
04-17 14:00
04-17 16:00
04-17 18:00
04-17 20:00
04-17 22:00
#56 Measurement, NH3 2013-04-19 11:08:00
Interlock Close Laser On Frequency 474.833 TEC1 12.19 Instrument 30.80 In 957.100 Flow 208.000

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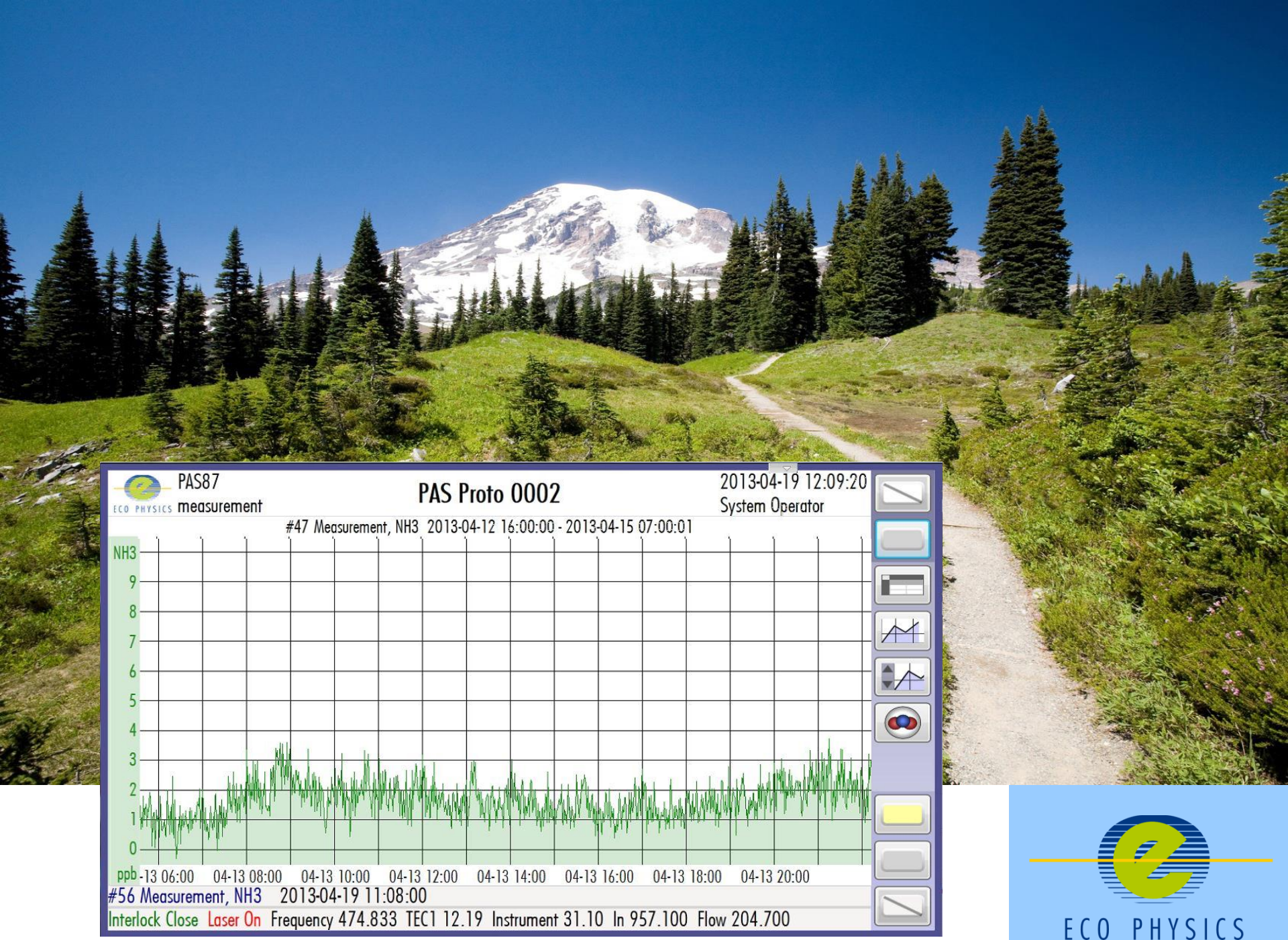
PAS87
ECO PHYSICS measurement
PAS Proto 0002
2013-04-19 12:09:20
System Operator
#47 Measurement, NH3 2013-04-12 16:00:00 - 2013-04-15 07:00:01
NH3
9
8
7
6
5
4
3
2
1
0
ppb
-13 06:00
04-13 08:00
04-13 10:00
04-13 12:00
04-13 14:00
04-13 16:00
04-13 18:00
04-13 20:00
#56 Measurement, NH3 2013-04-19 11:08:00
Interlock Close Laser On Frequency 474.833 TEC1 12.19 Instrument 31.10 In 957.100 Flow 204.700

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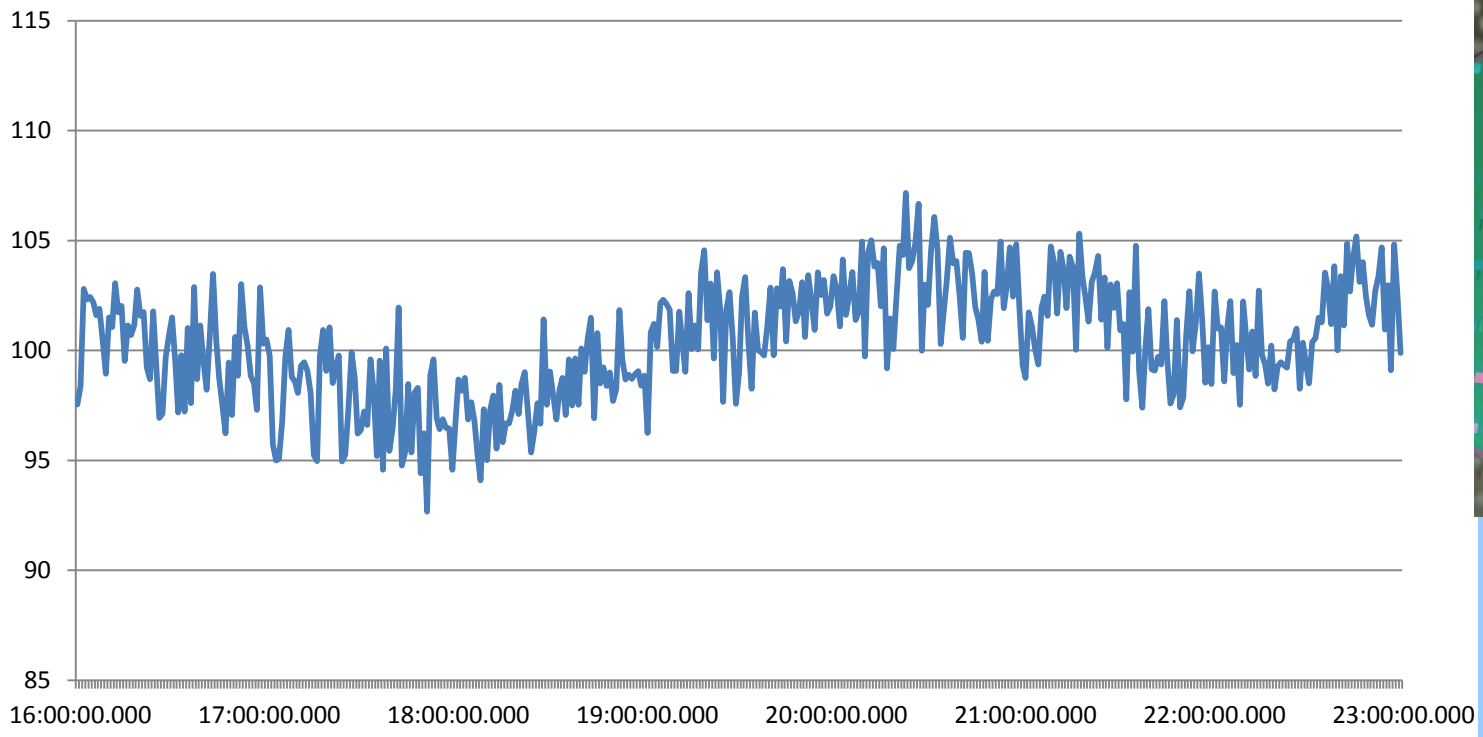
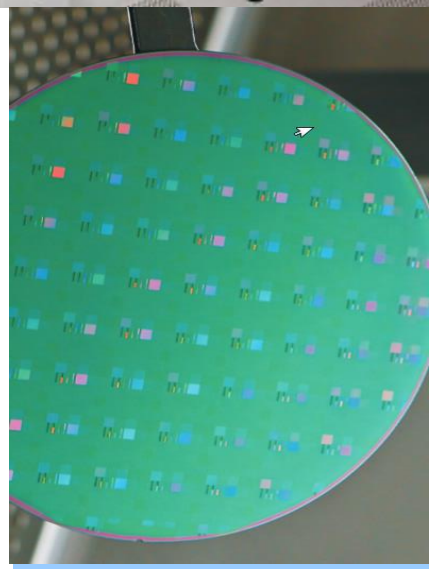
Cleanroom Monitoring

Chemical mechanical polishing (CMP)





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Characteristics PAS 87

- Direct measurement of ammonia concentration.
- Compact stand alone instrument
- Maintenancefree laser unit
- Long maintenance intervals
- Low operating costs
- Modern user interface (Touchscreen - 7“-Display)
- Internal PC (→ USB, LAN, RS232), Data Logging

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Specifications

PAS 87

Specifications

Measuring ranges	four freely selectable ranges from 10–5'000 ppb
Min. detectable concentration	< 0.5 ppb*
Noise at zero point (1 σ)	< 0.25 ppb*
Lag time	<15 sec
Rise time (0–90%)	< 50 – 150 sec **
Temperature range	15–30 °C
Humidity tolerance	0–95% rel. h (non-condensing, ambient air and sample gas)
Sample flow rate	0.2 l/min
Input pressure	ambient, to be stabilized within ± 3 mbar
Power required	< 250 VA (incl. sample pump)
Supply voltage	100 - 230 V/50–60 Hz

Interface	RS 232, LAN, USB (4x) DVI video out
Analog output	Optional: External interface box connected via USB
Dimensions	height: 178 mm (7 ") width: 450 mm (19 ") with moulding: 495 mm depth: 545 mm
Weight	39 kg
Delivery includes	PAS 87 analyzer, power cable, operator's manual
Standard	PAS 87

* depending on filter setting
** depending on the concentration

ECO PHYSICS reserves the right to change these specifications without notice.

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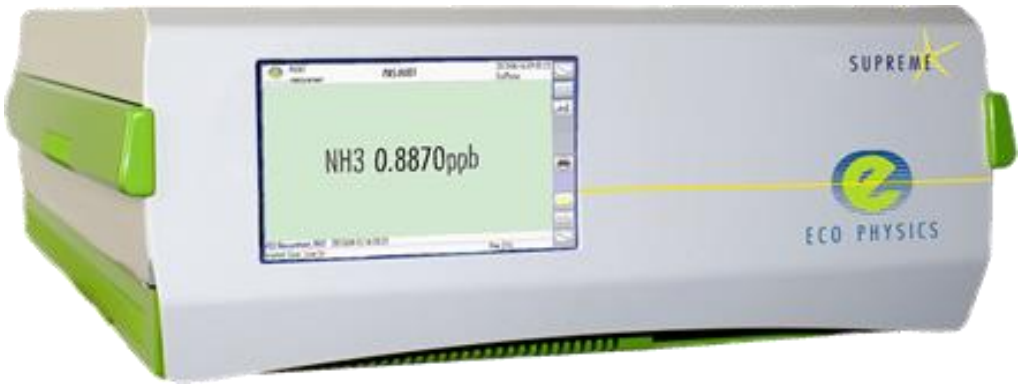
Photoacoustic Spectroscope

- PAS 87



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