Exhaust gas cleaning for small wood fired appliances

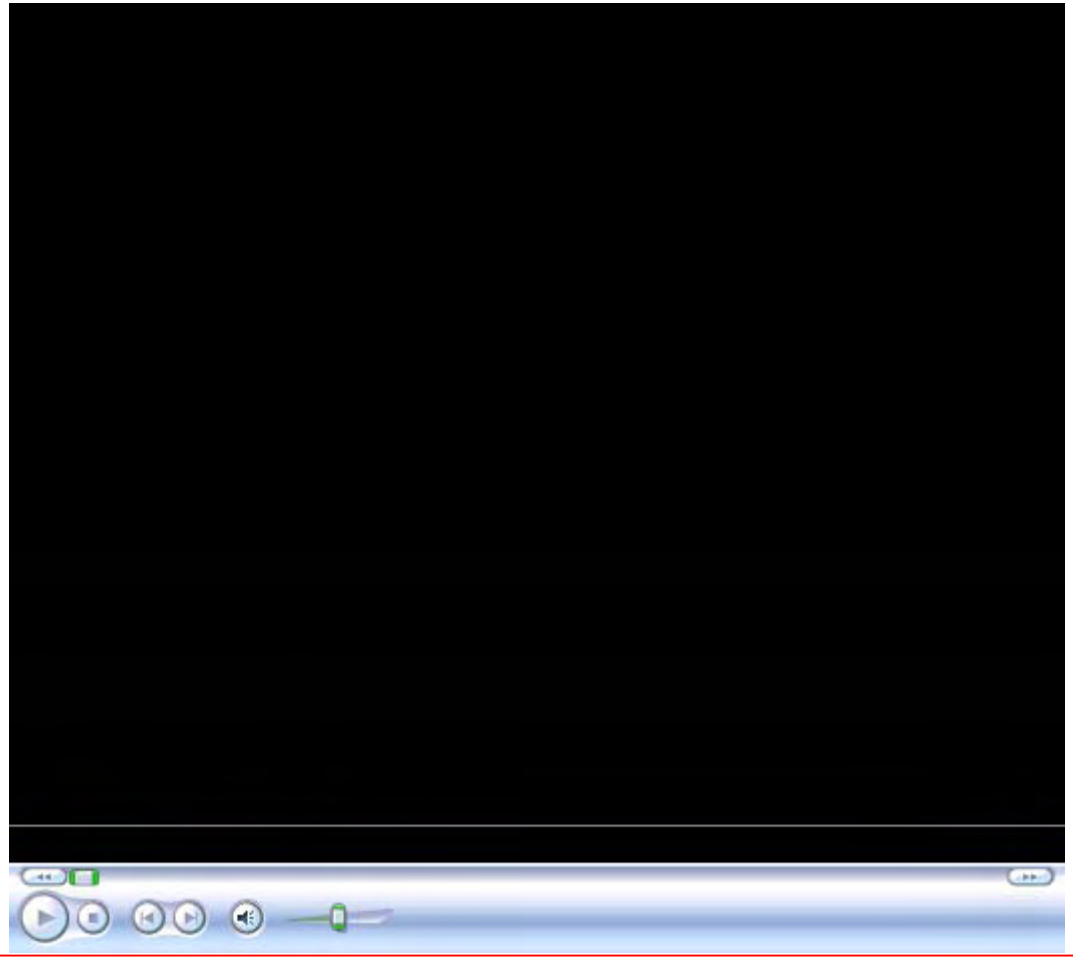
recent progress and field test results

- Introduction
- initial Situation
- R&D-Project
- Results
- Conclusion

www.minipab.ch

Introduction

TV report SF1 DRS, MTW 7. Okt. 2004



Particles !

Effects of PM_{10} concentrations in ambient air?

- WHO – report 1999 (F/CH/A):
  3300 premature deaths in Switzerland,
  economic costs ~6.6 Mrd. CHF
- medical studies:
  pulmonar and cardio-vascular diseases, cancer
  human immune systems reacts to bigger particles
- smell
- neighbourhood problems

Recent european studies and directives

Sources of PM_{10} pollution

human activities

- Industry
- Traffic

- Residential heating

natural sources

- sandstorms
- Wild fires
- Vulcano eruptions
- Polls

Example: Sidney

Contribution of wood smoke to air particle pollution

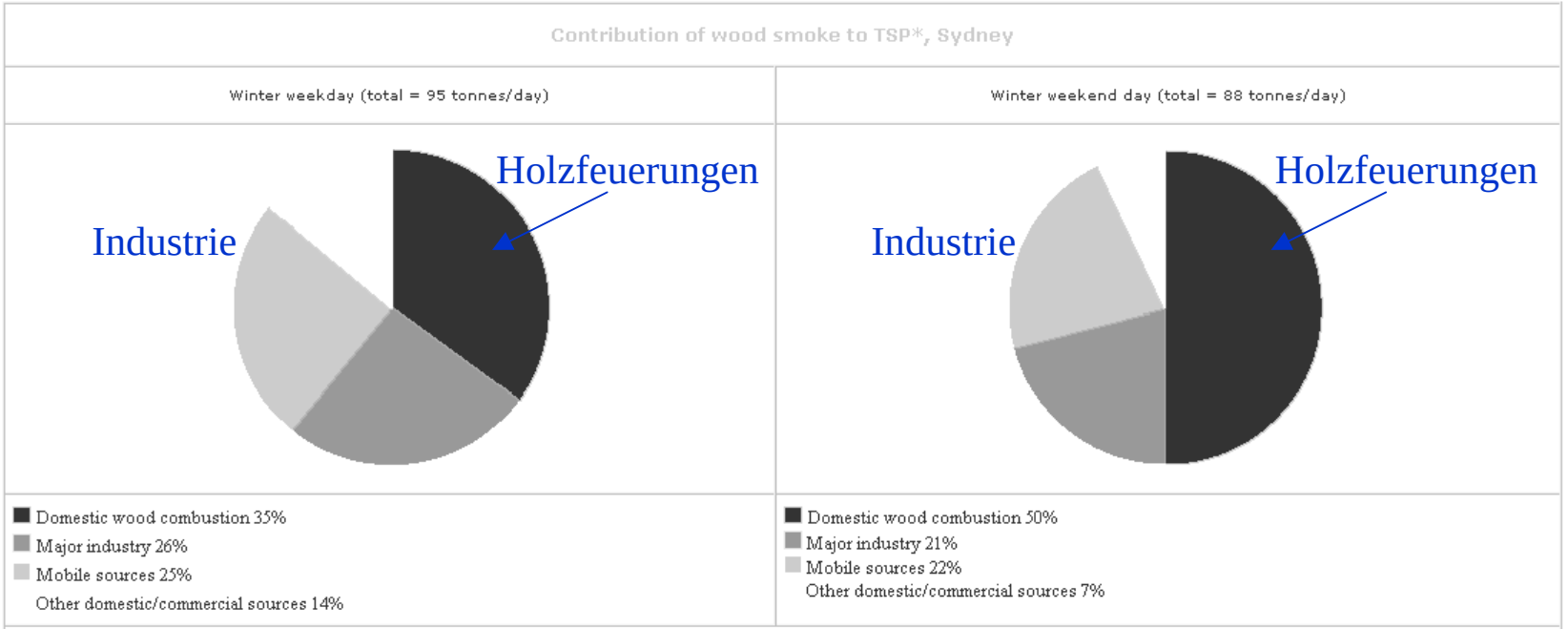
In winter, there is more air particle pollution caused by wood smoke than any other single source.

In Sydney, solid fuel heaters contribute 40% of air particle pollution. On a winter weekend it can be as high as 50%. In colder climates, such as Armidale, the contribution of wood smoke to pollution is higher.

The fine particles in wood smoke contribute to the brown haze often seen on still winter mornings.

The figure below shows the relative contributions of weekday winter sources of particle pollution. It indicates that domestic wood combustion contributes 35% of total suspended particle (TSP) levels. On weekends this contribution can reach 50%.

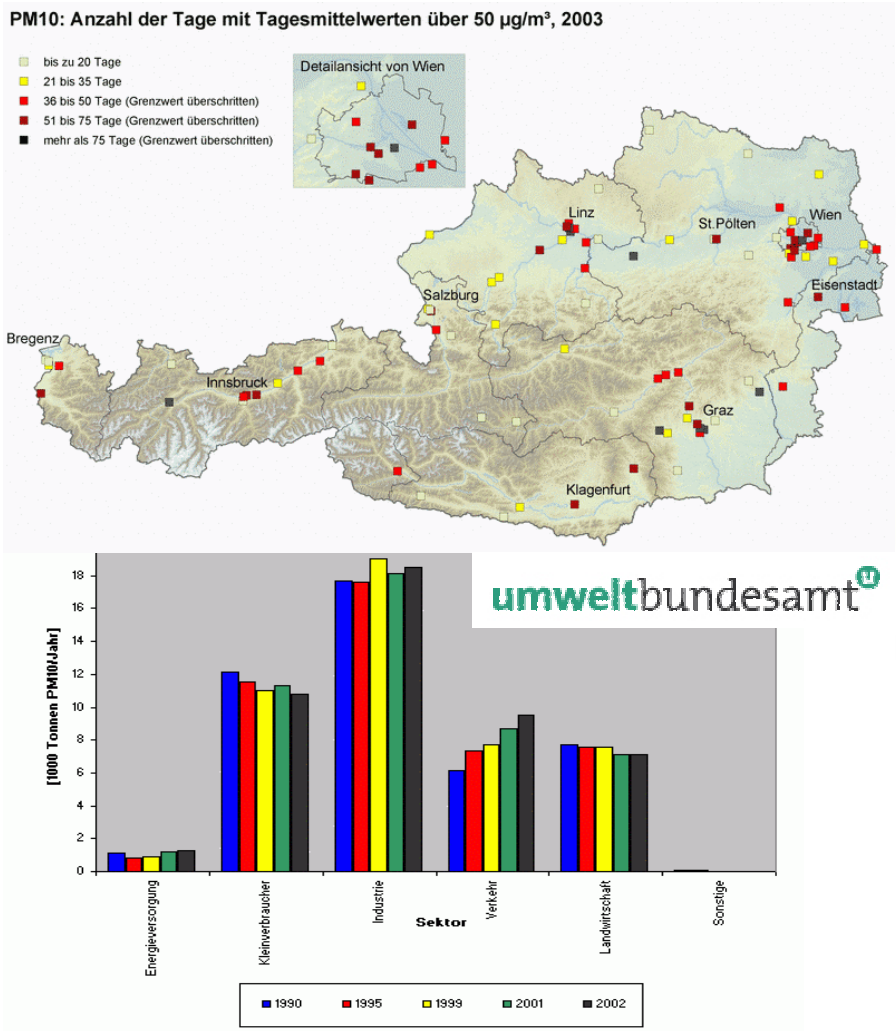
Contribution of wood smoke to TSP*, Sydney

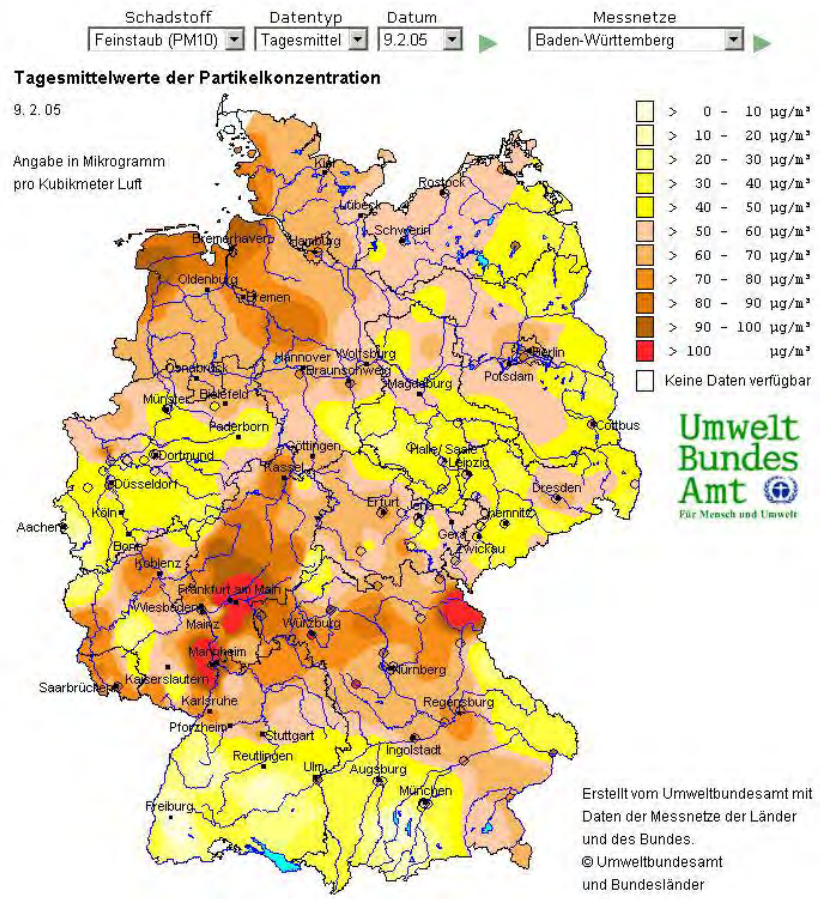


* TSP = total suspended particles. Measurements of TSP are used to provide an indication of the level of coarse particles in the atmosphere.

Source: Carnovale, F., Tilley, K., Stuart, A., Carvalho, C., Summers, M. & Erikson, P. (eds) 1997, *Metropolitan Air Quality Study – Air Emissions Inventory*, consultant's report to the NSW Environment Protection Authority, Sydney.

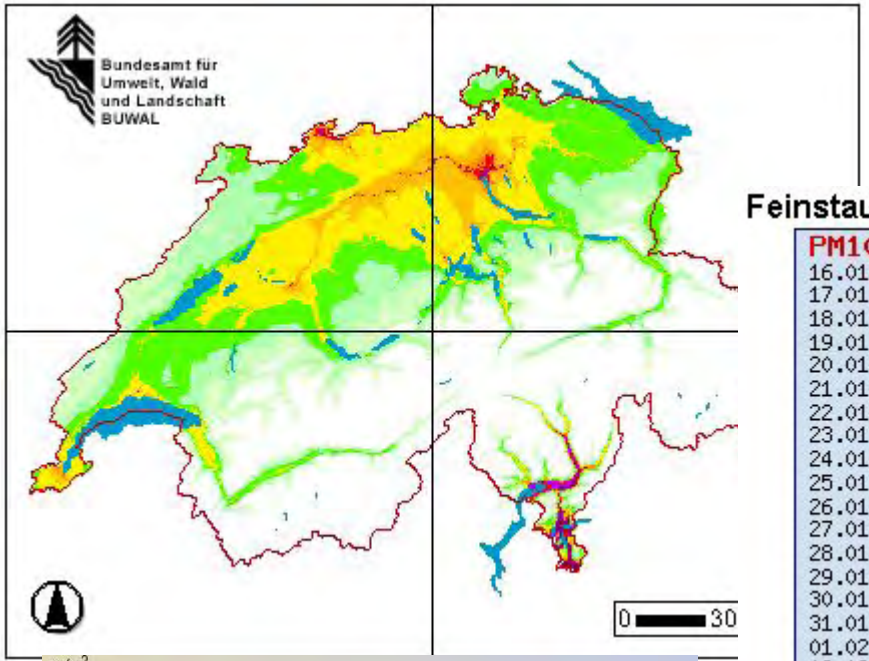
Examples: Austria, Germany

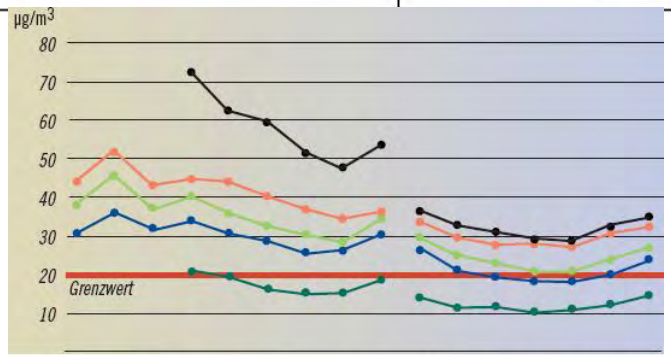




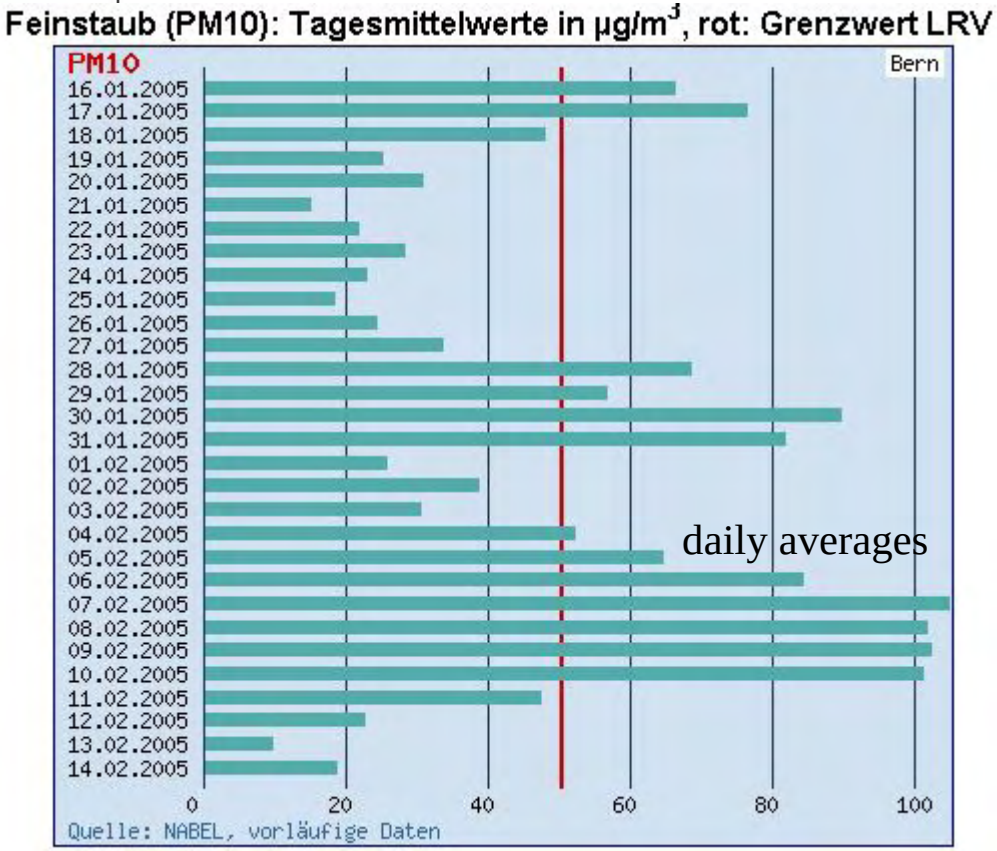
Example Switzerland

„…the annual limit for PM10 of 20 µg/m3 is exceeded by 50% in the Rue Dr César-Roux.“ (BUWAL Magazin Umwelt 4/2004)





NABEL-Messstation Bern

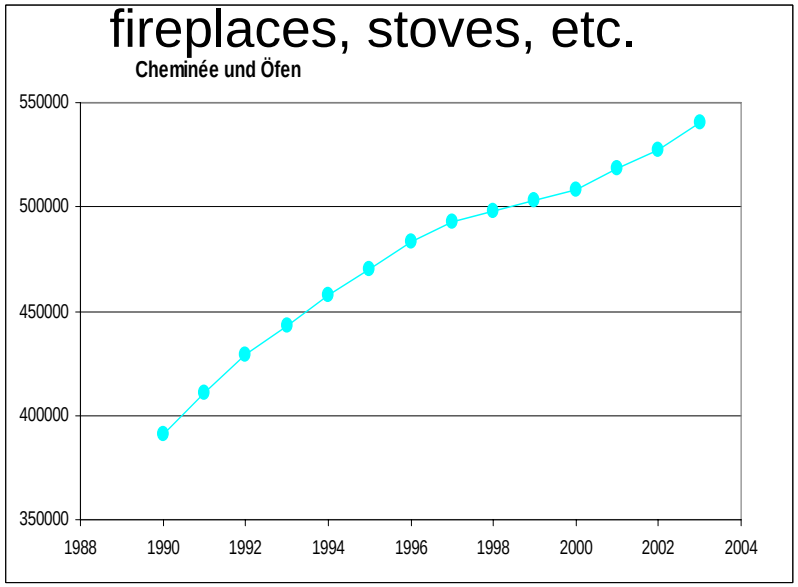


daily averages

Background

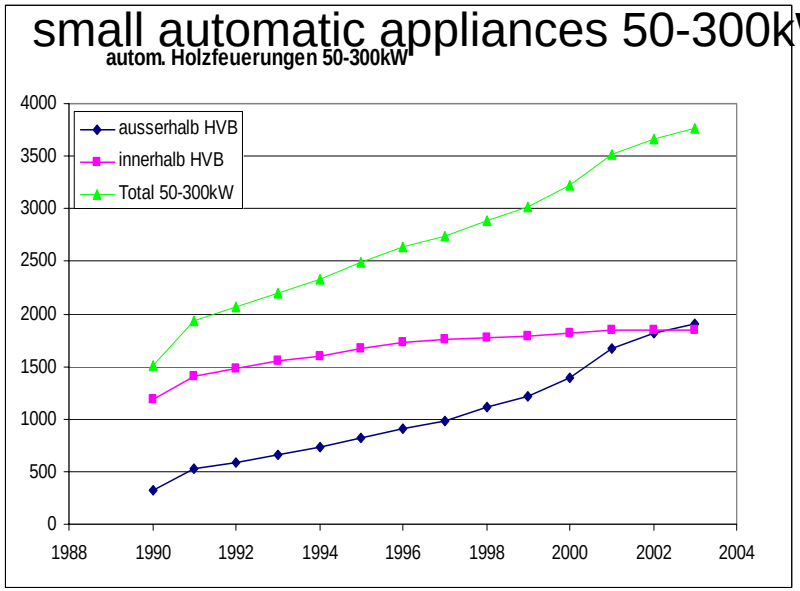
wood furnaces, such as stoves or fireplaces are increasingly popular

fireplaces, stoves, etc.



(Swiss „Holzenergiestatistik“ Cat. 1-5)

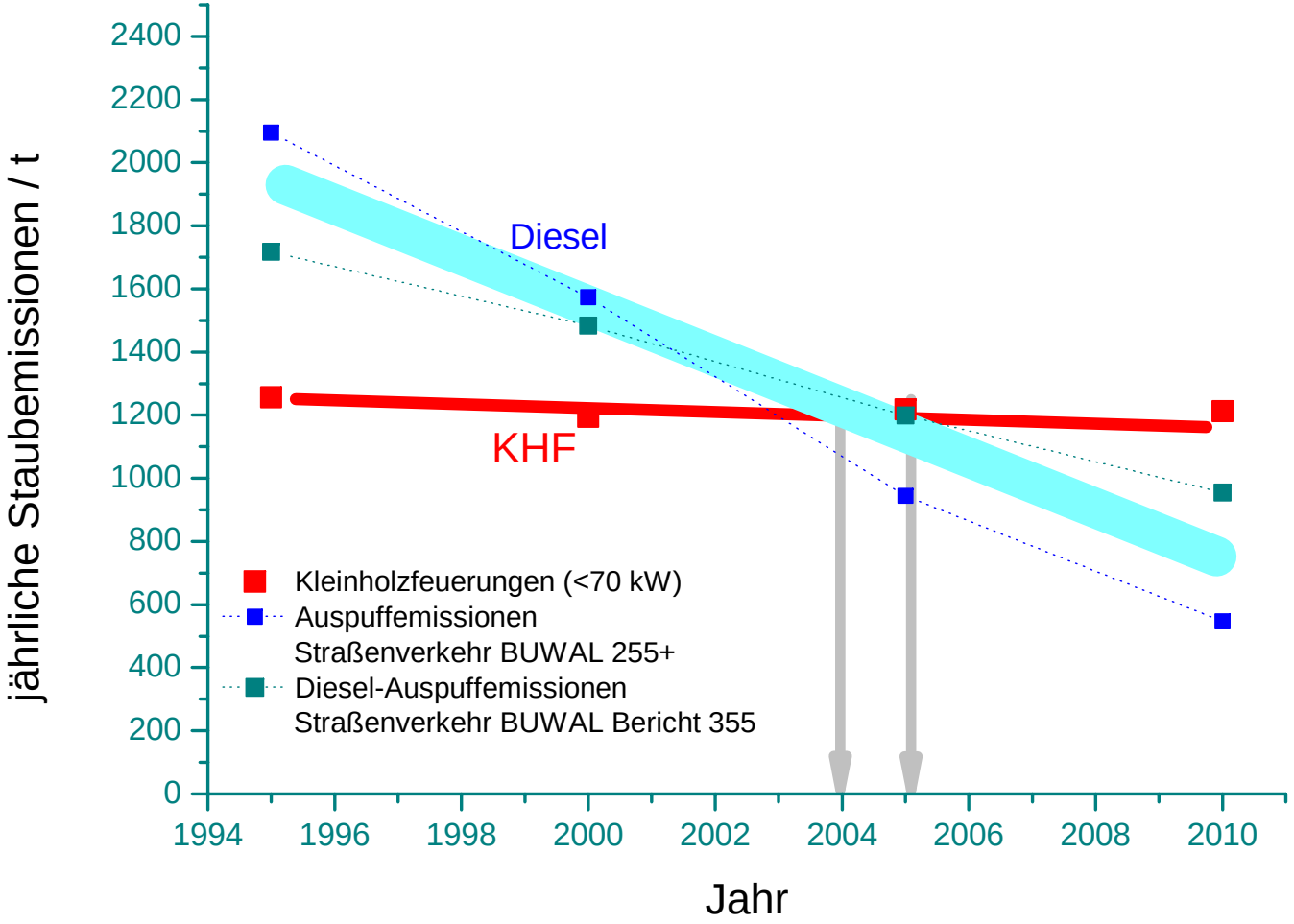
small automatic appliances 50-300kW.



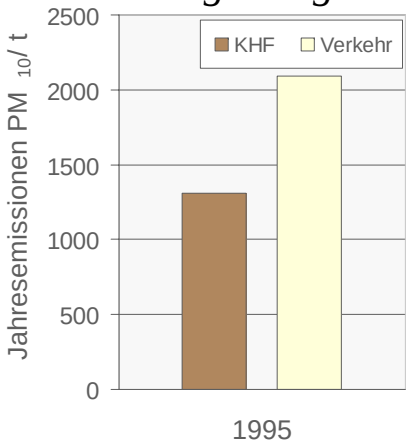
(Swiss „Holzenergiestatistik“ Cat. 12&13)

Dust Emissions in Switzerland

small wood fired furnaces / tail pipe emissions road traffic



Situation at the beginning



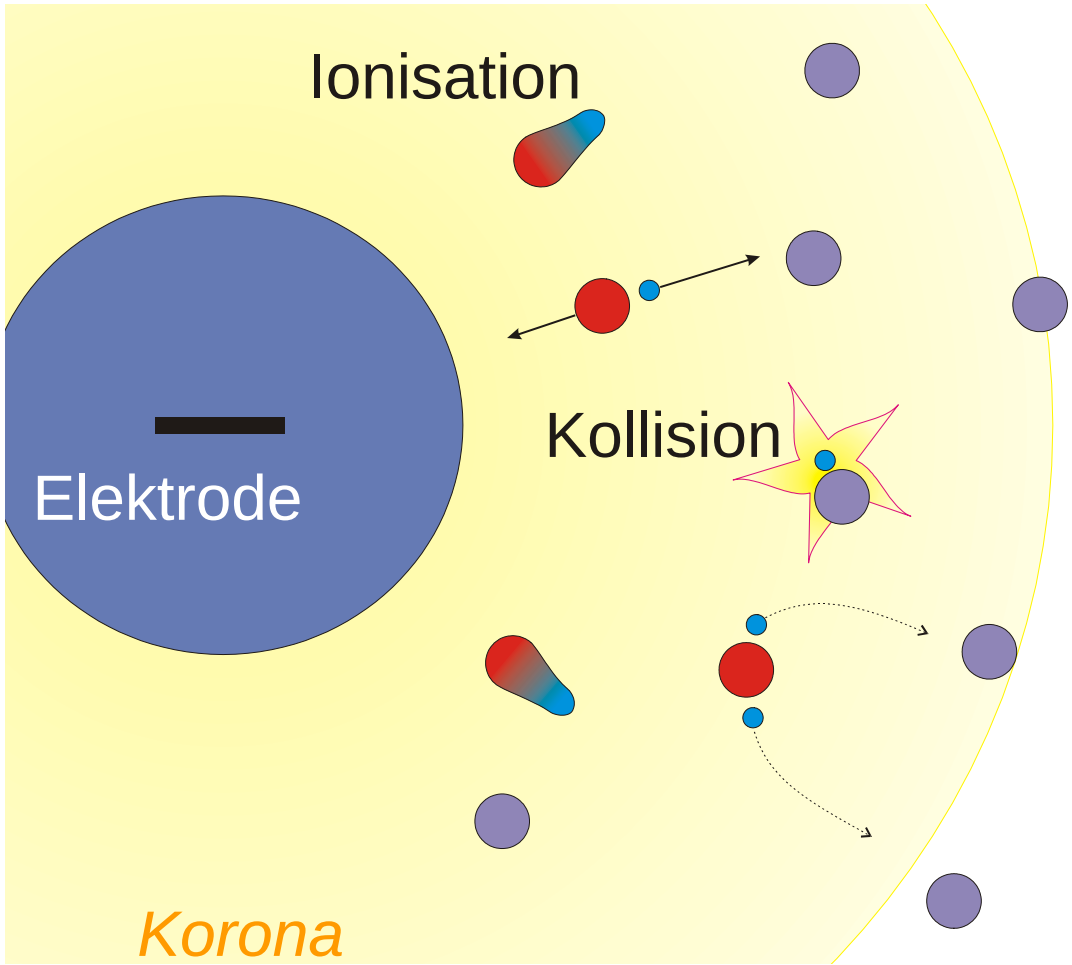
Background

- Situation at the beginning of the project:

  Activities in sectors traffic and industry
  Promotion of renewable sources of energy
  increase of wood combustion
  increasing realisation of emission PM10 problem

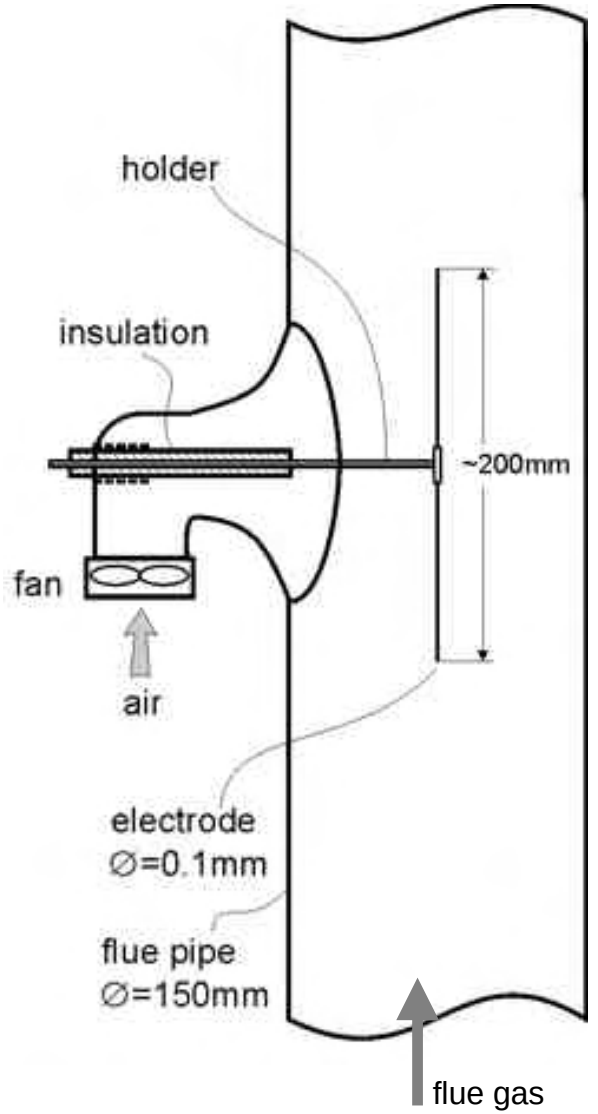
→ Development of a solution for small heating appliances

Basic Principle of an ESP

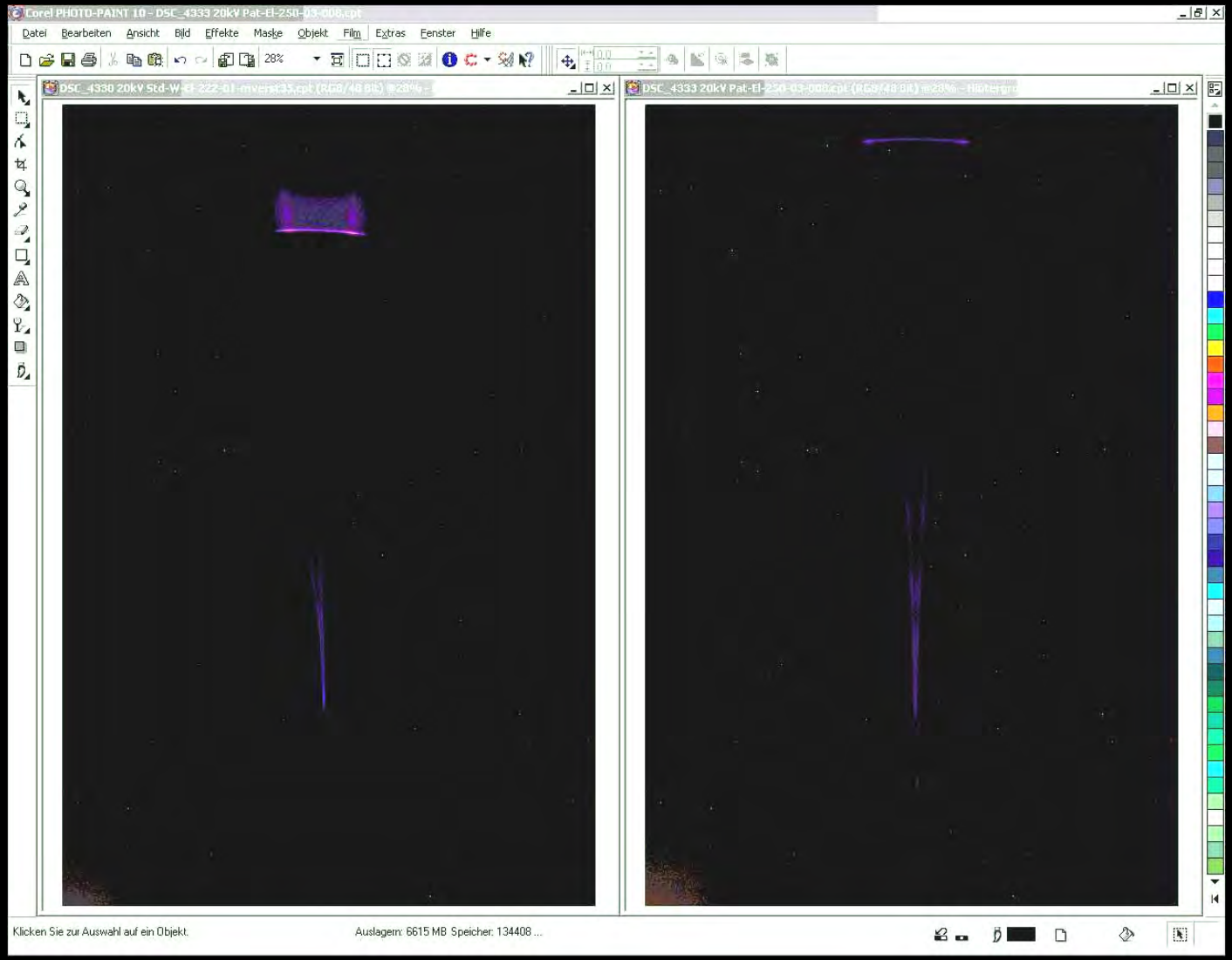


construction

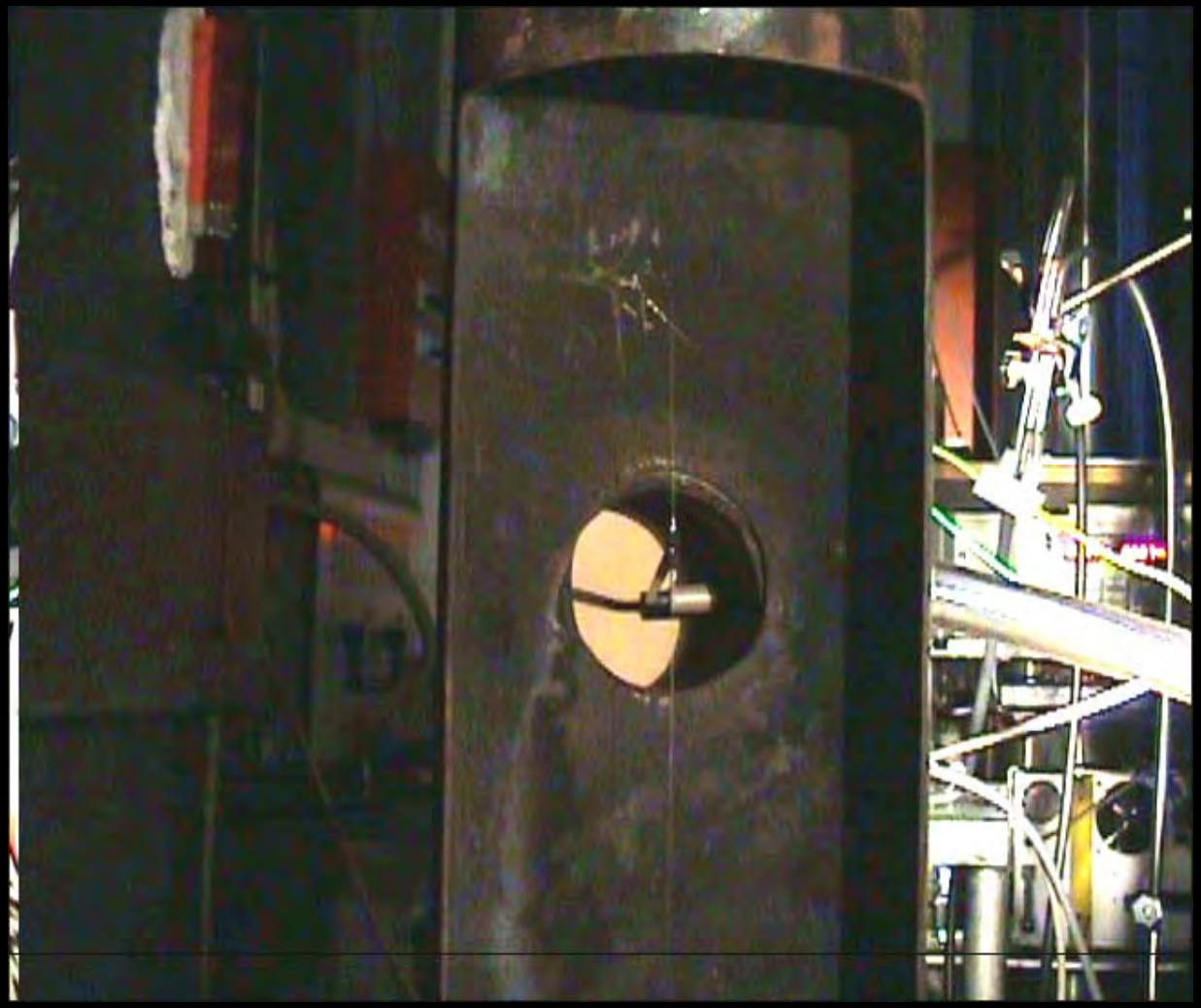
- straight wire
- single holder
- air flow

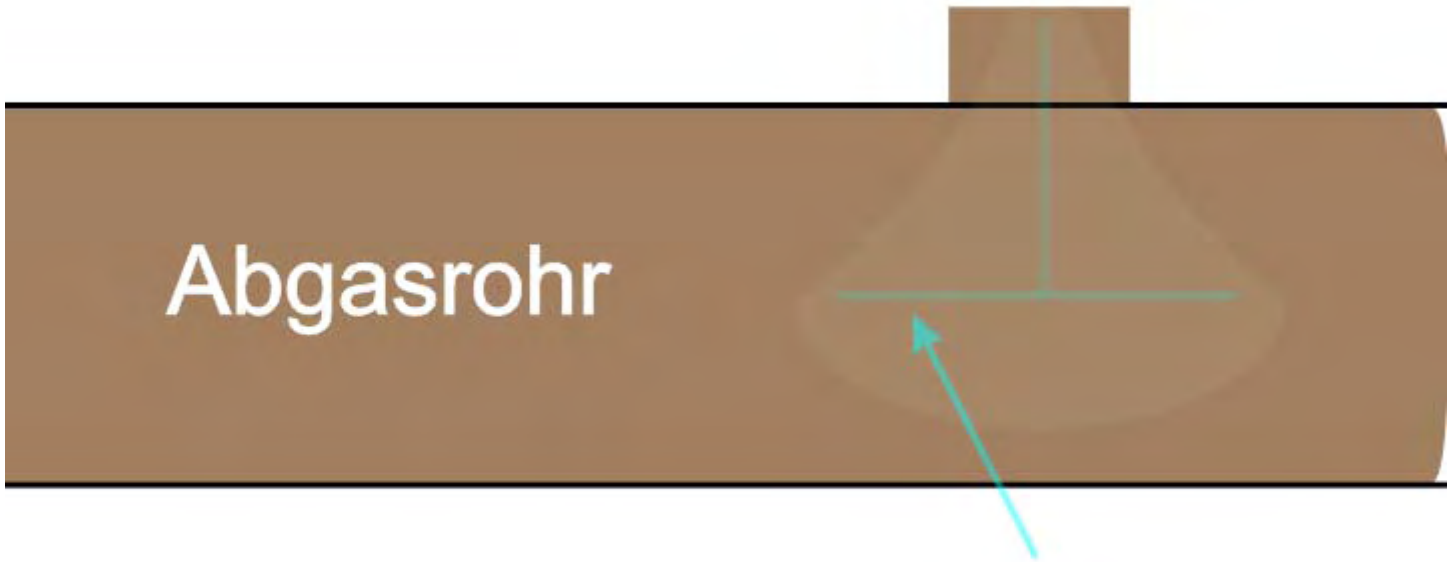


Corona at the electrode



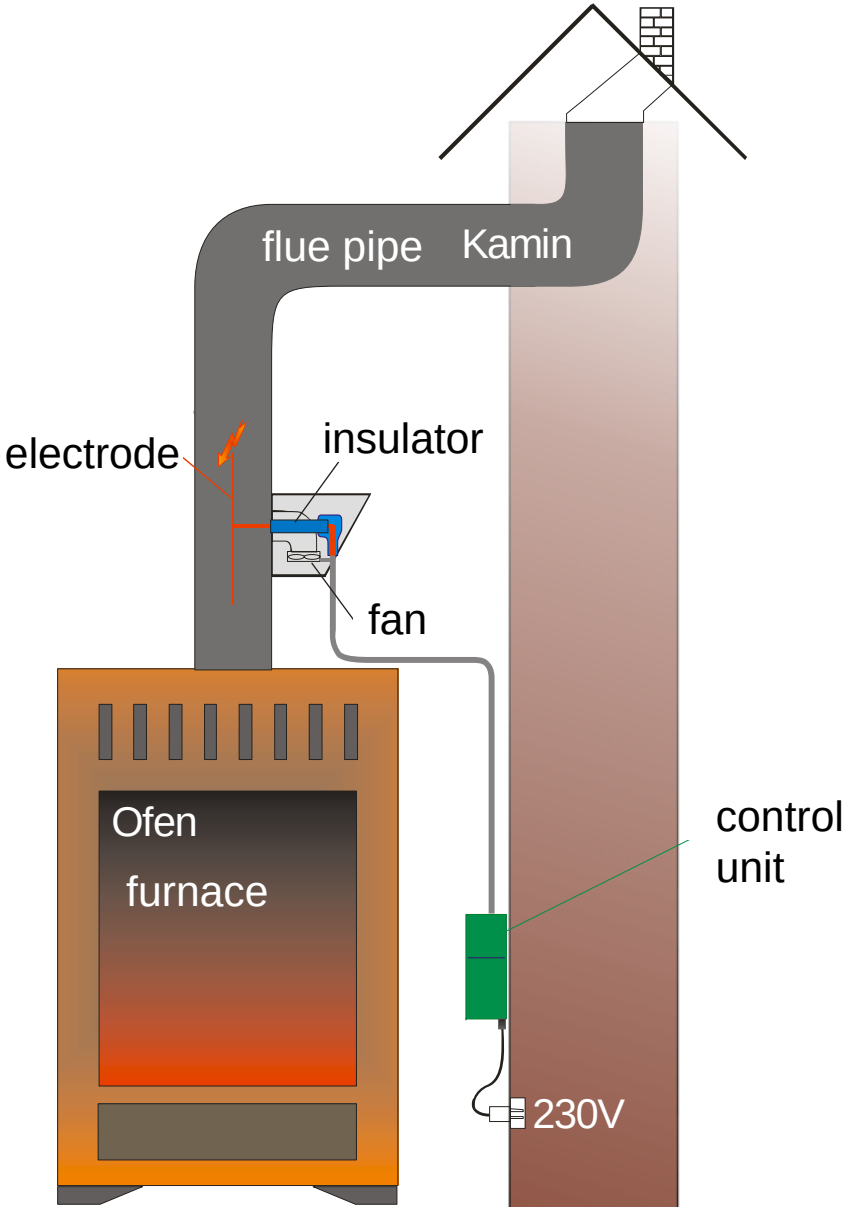
Corona at the electrode



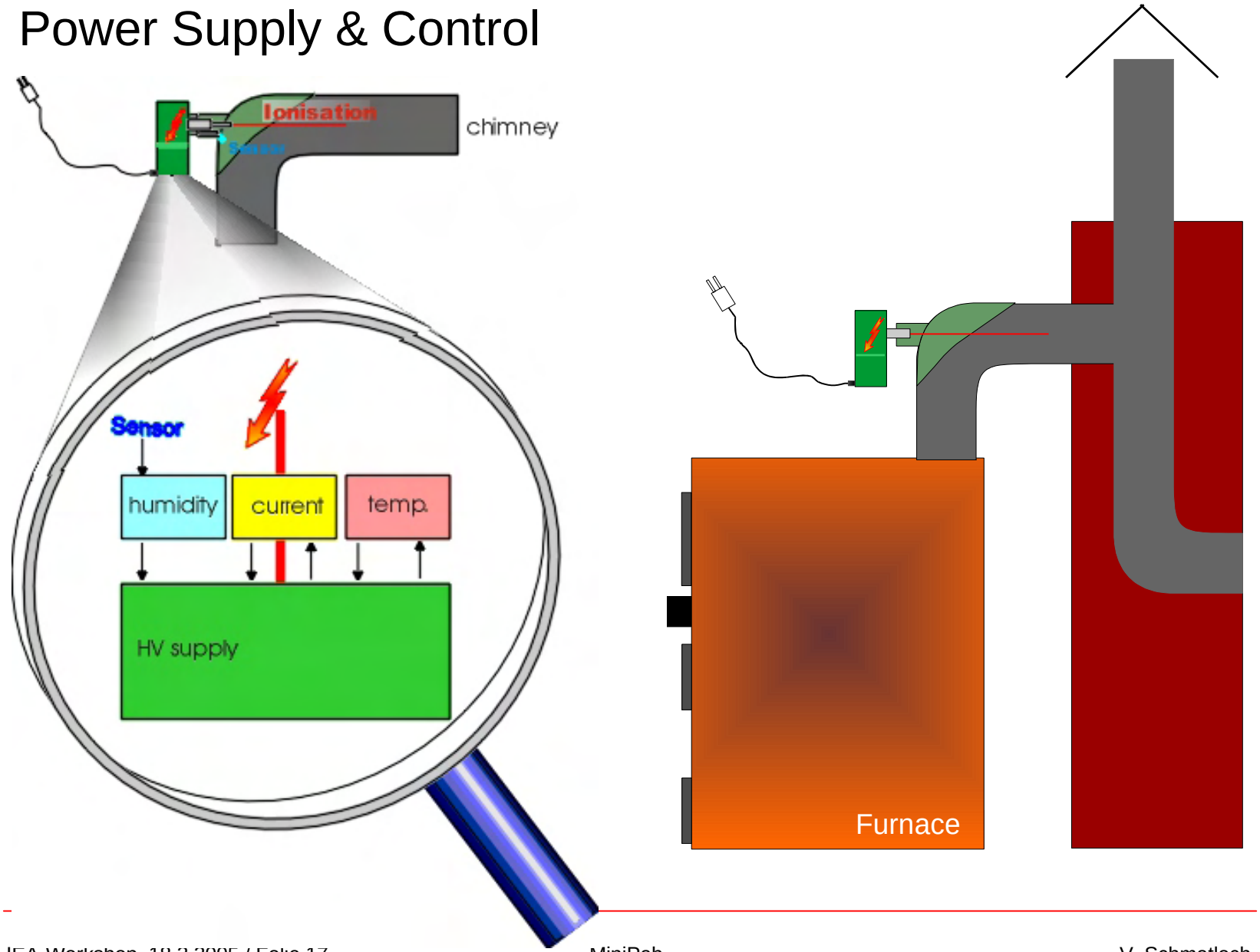

Abgasrohr

Obective

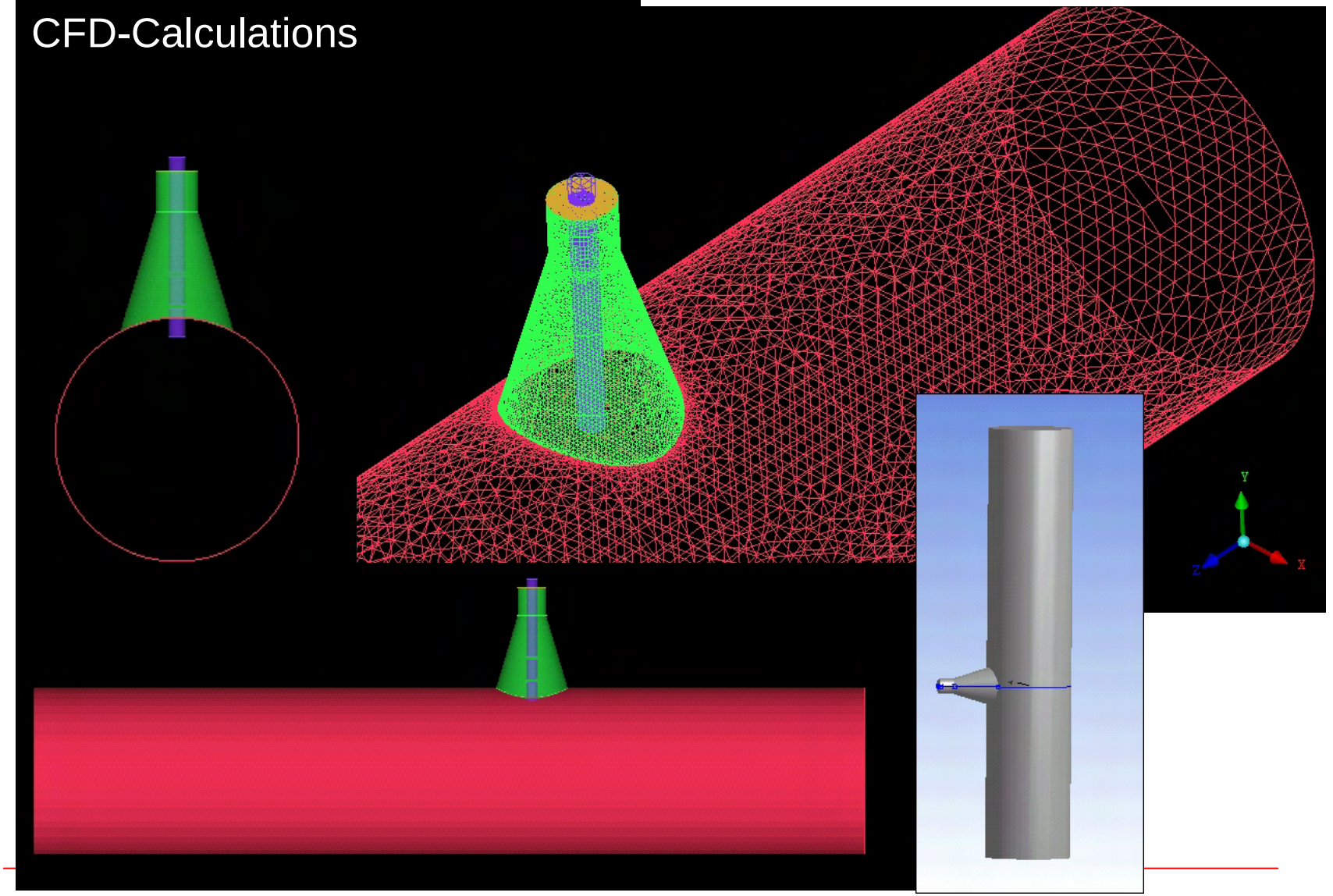
- **low cost**
- **small size**
- **easy handling**
- **low maintenance**
- **reasonable efficiency**



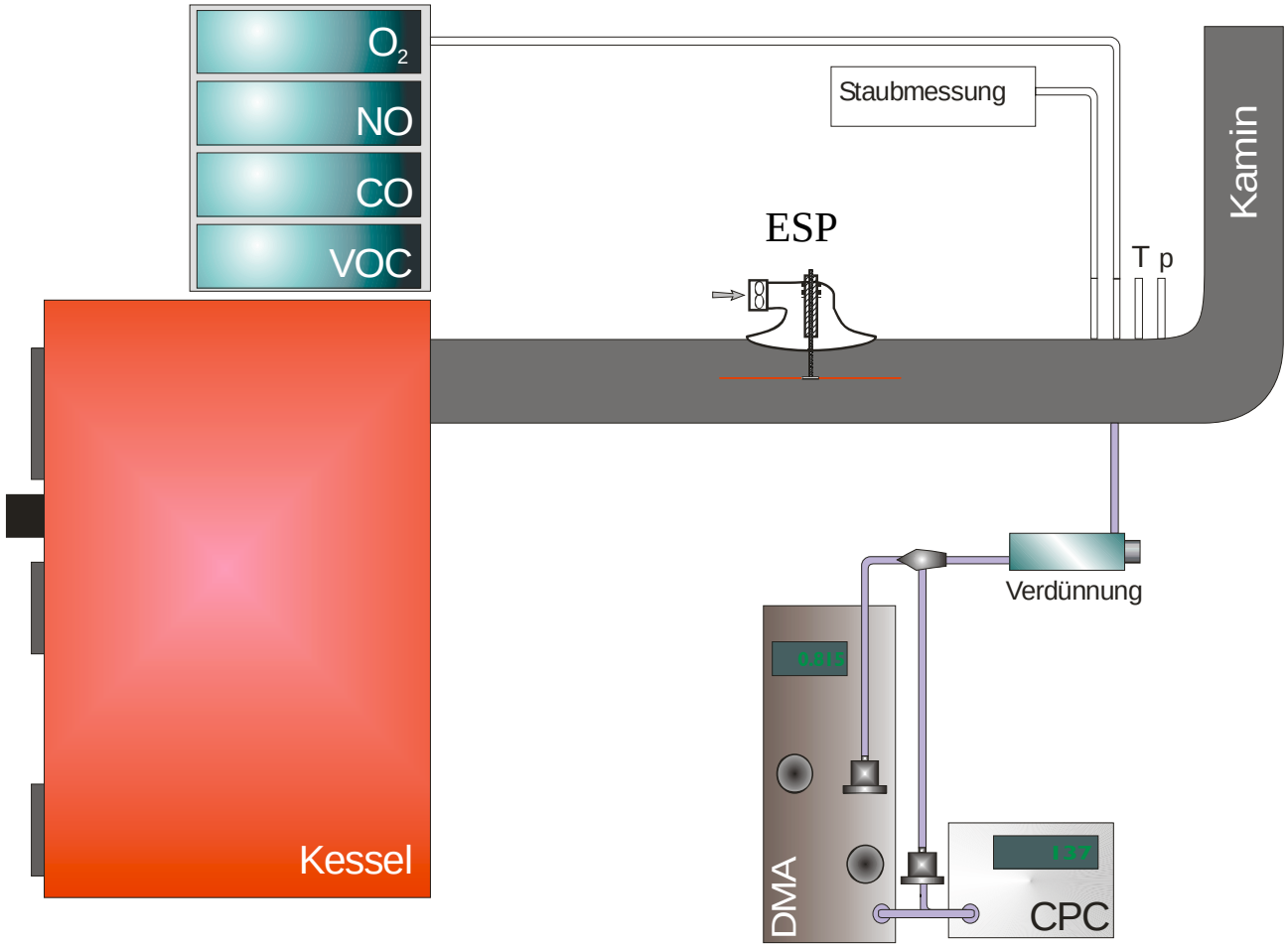
Power Supply & Control



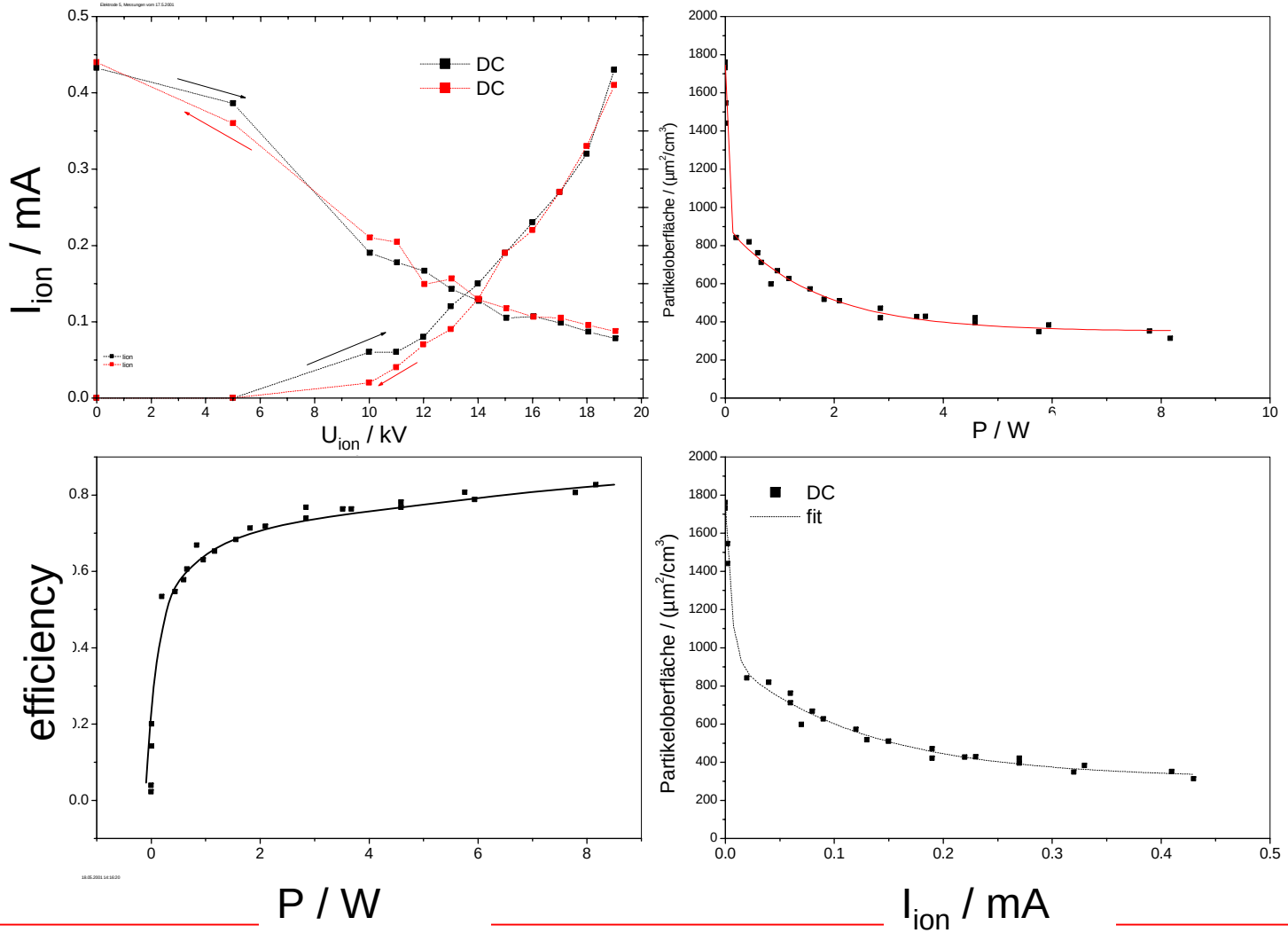
CFD-Calculations



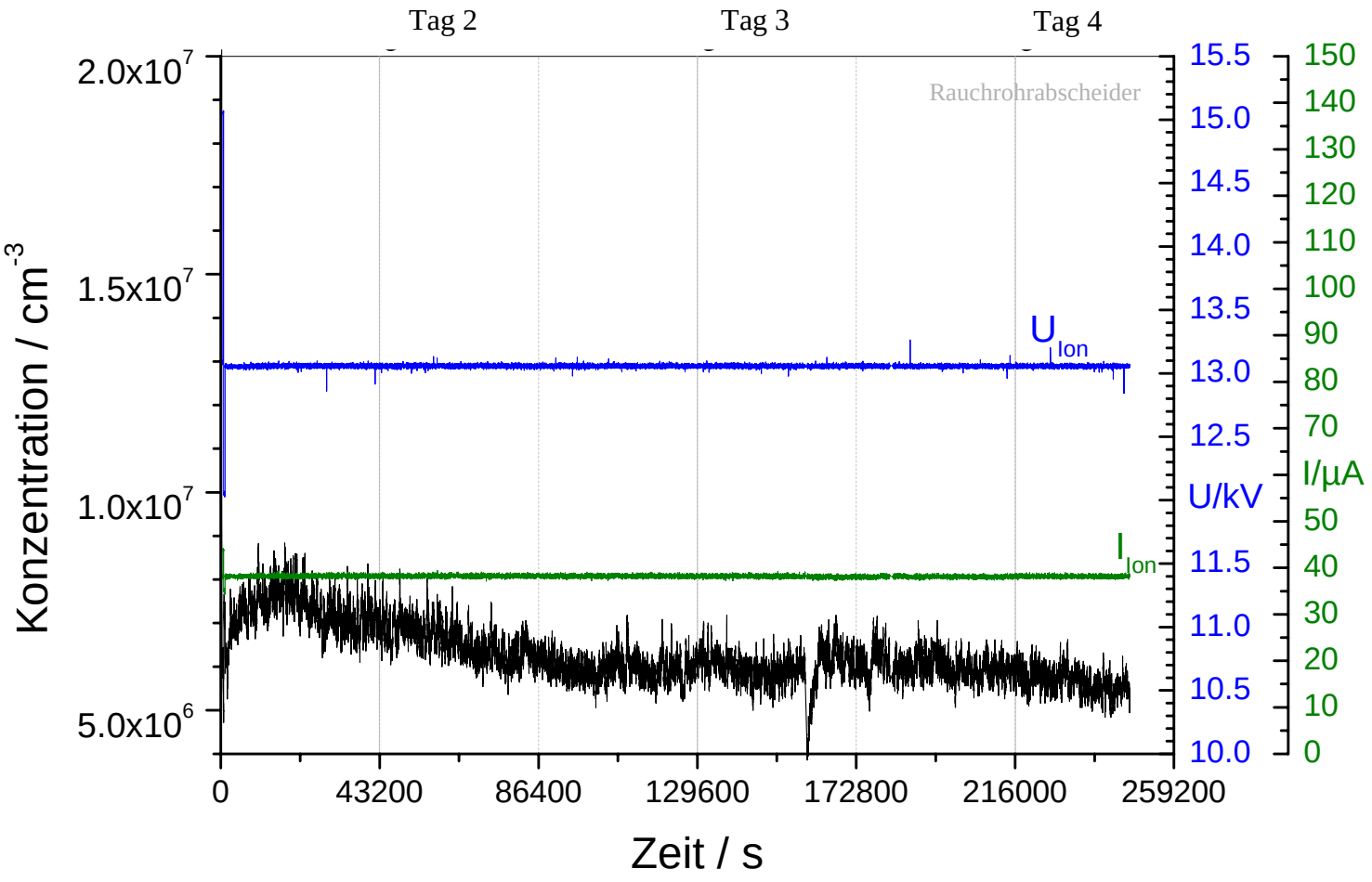
Experimental setup



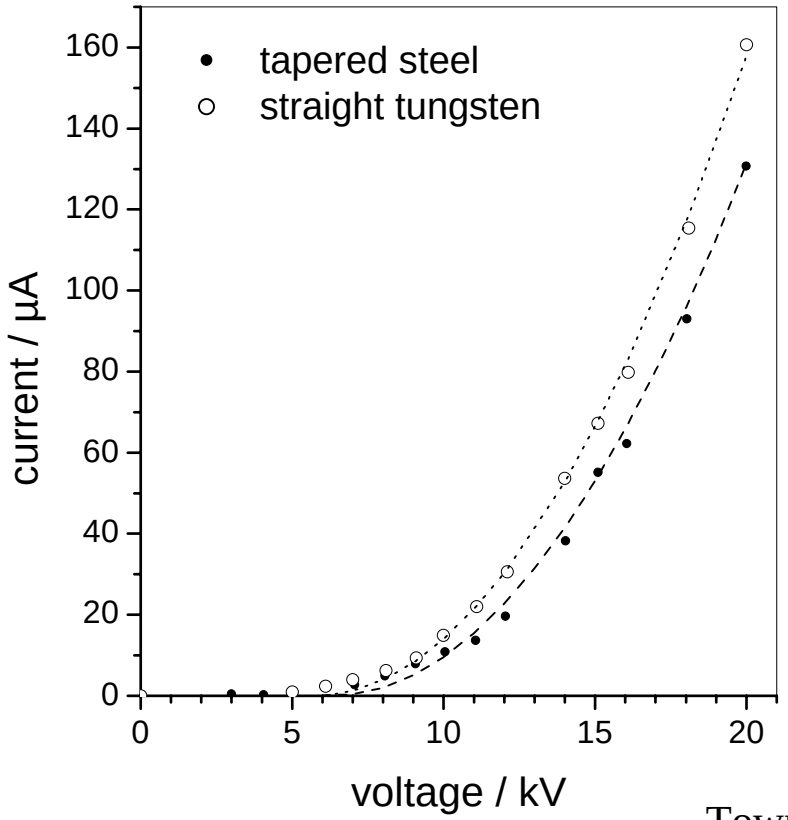
Electrical Characteristics

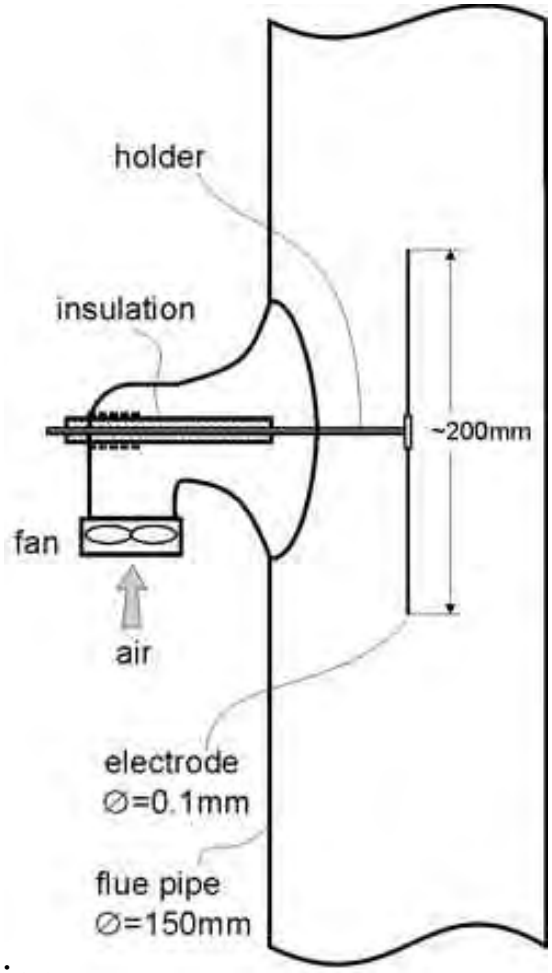


Electrode 5, continuous operation, pellet boiler



Strom-Spannungs-Kennlinien, Drahtelektrode

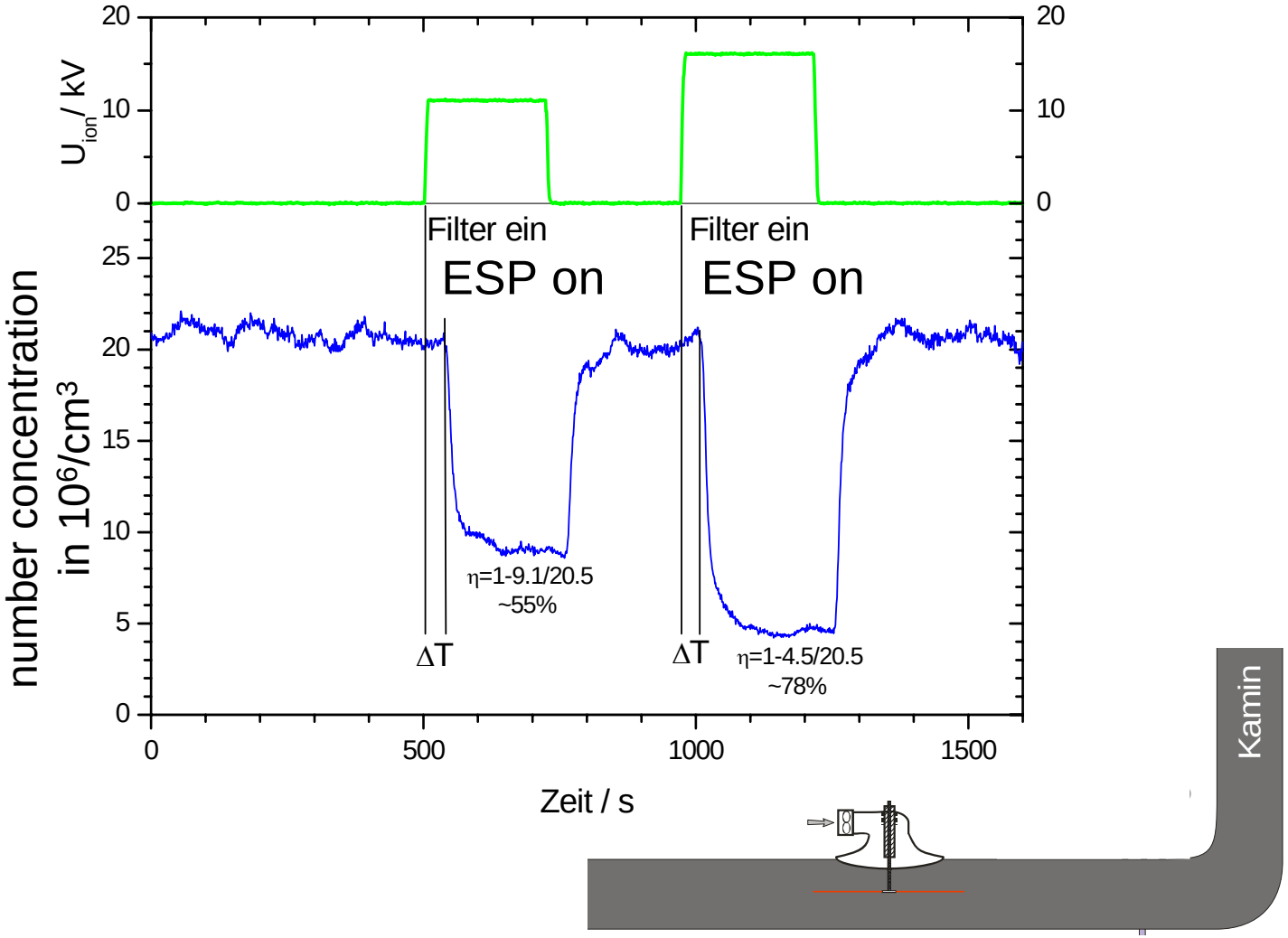




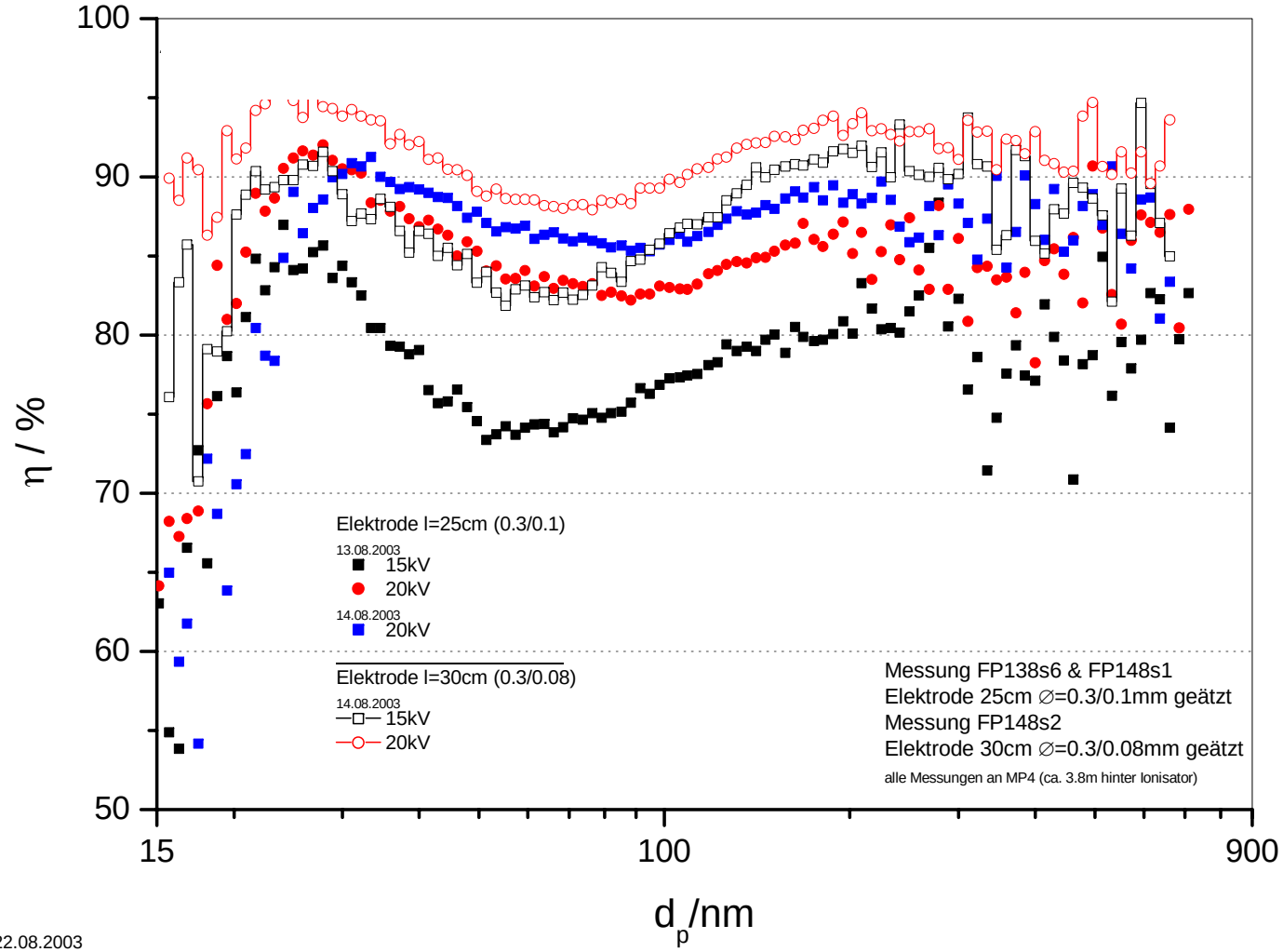
Townsend relation

$$I = k \cdot U \cdot (U - U_o)$$

ESP time response when switching on and off

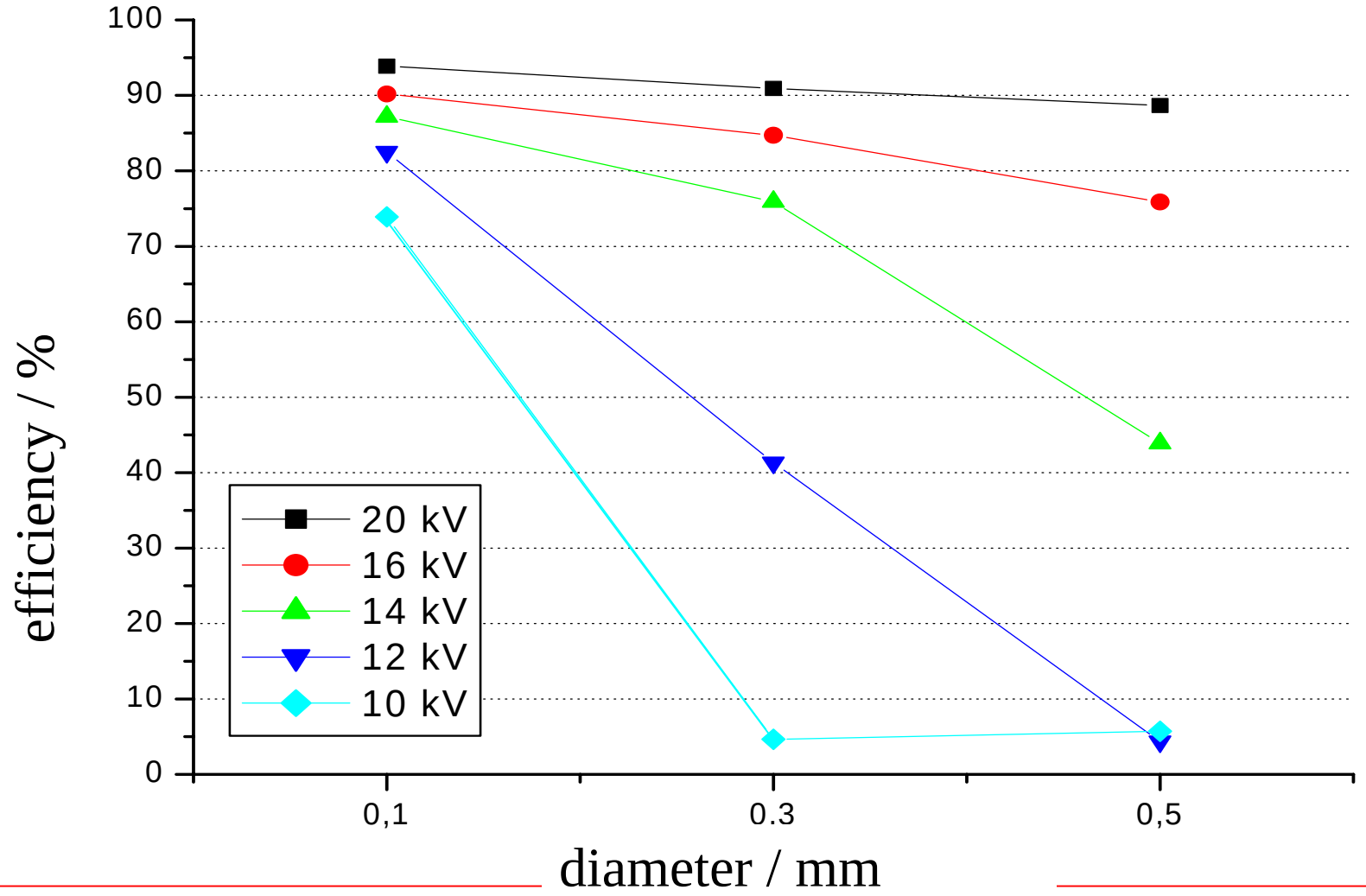


Collection efficiency vs. particle size

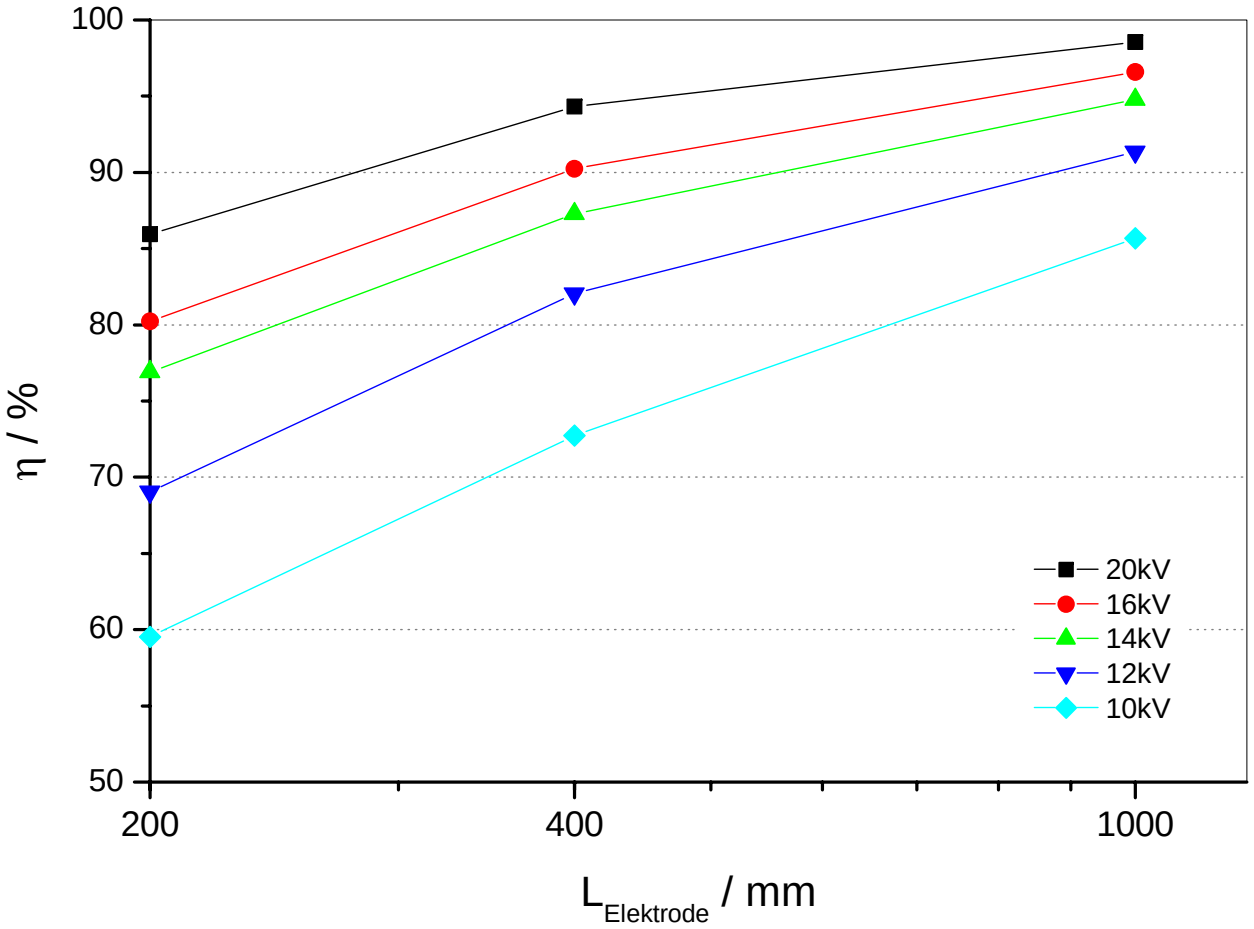


VFS137/22.08.2003

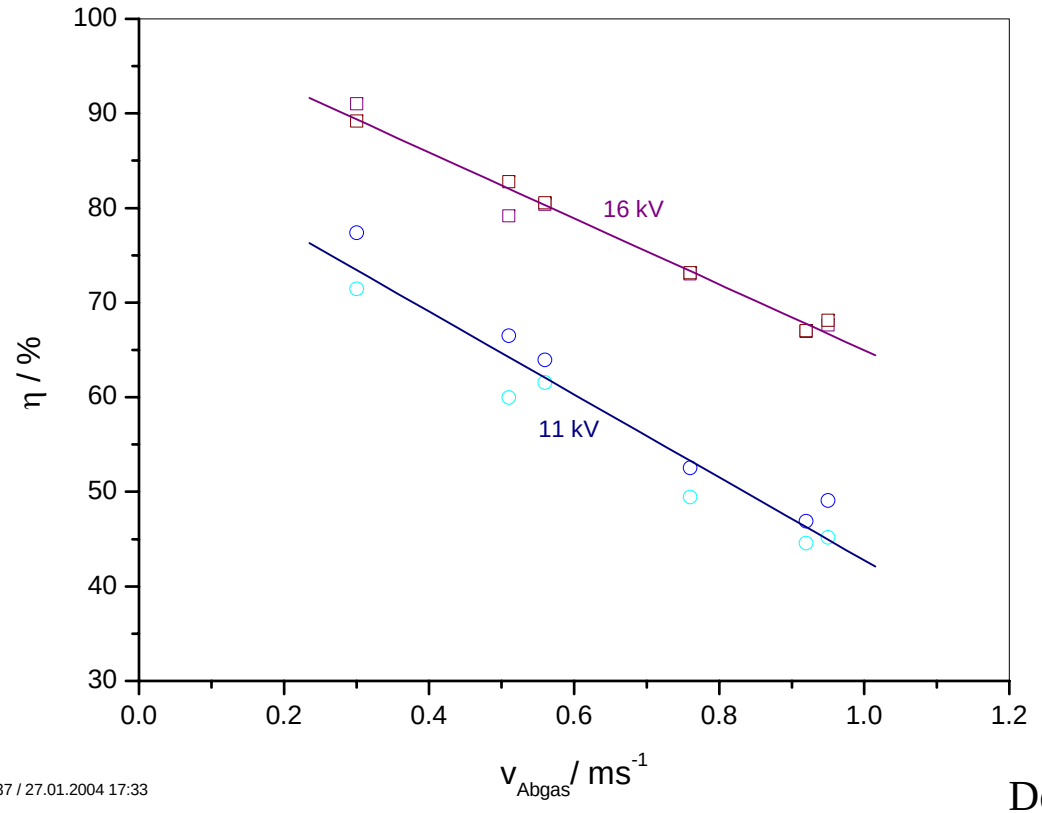
Effect of electrode diameter



Effect of electrode length(d = 0.1mm)



Effect of flue gas velocity



$\eta = 100 \cdot (1 - C_{nach}/C_{vor})$

Deutsch-Eq.:

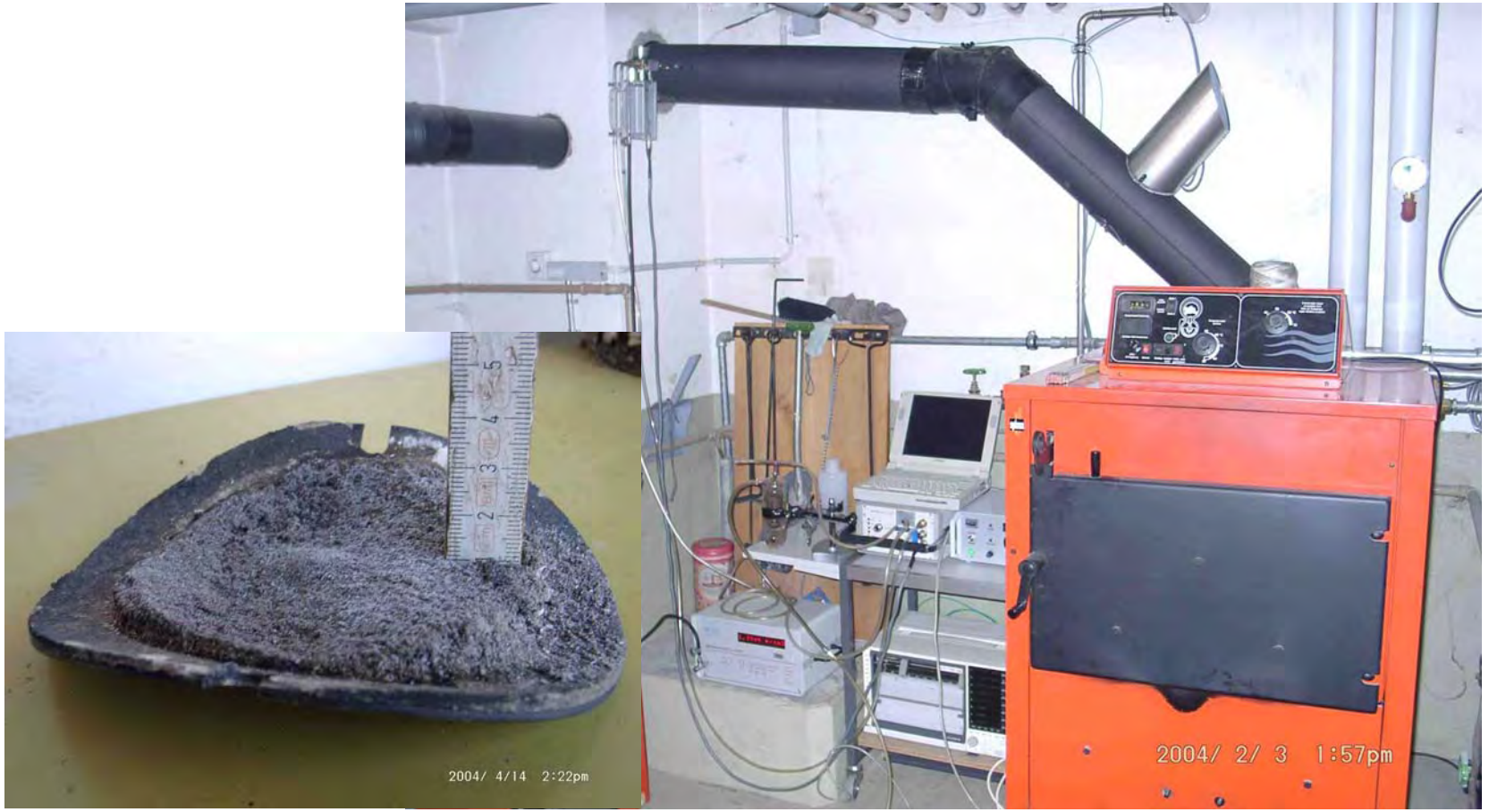
$1 - \eta \sim \exp(-V_{TE} \cdot A/Q)$

Field Tests

stove

fireplace

Field tests



Field tests

2001/02 : stove, ~50% efficiency

2003: fireplace und stove, ~70% / 55% efficiency

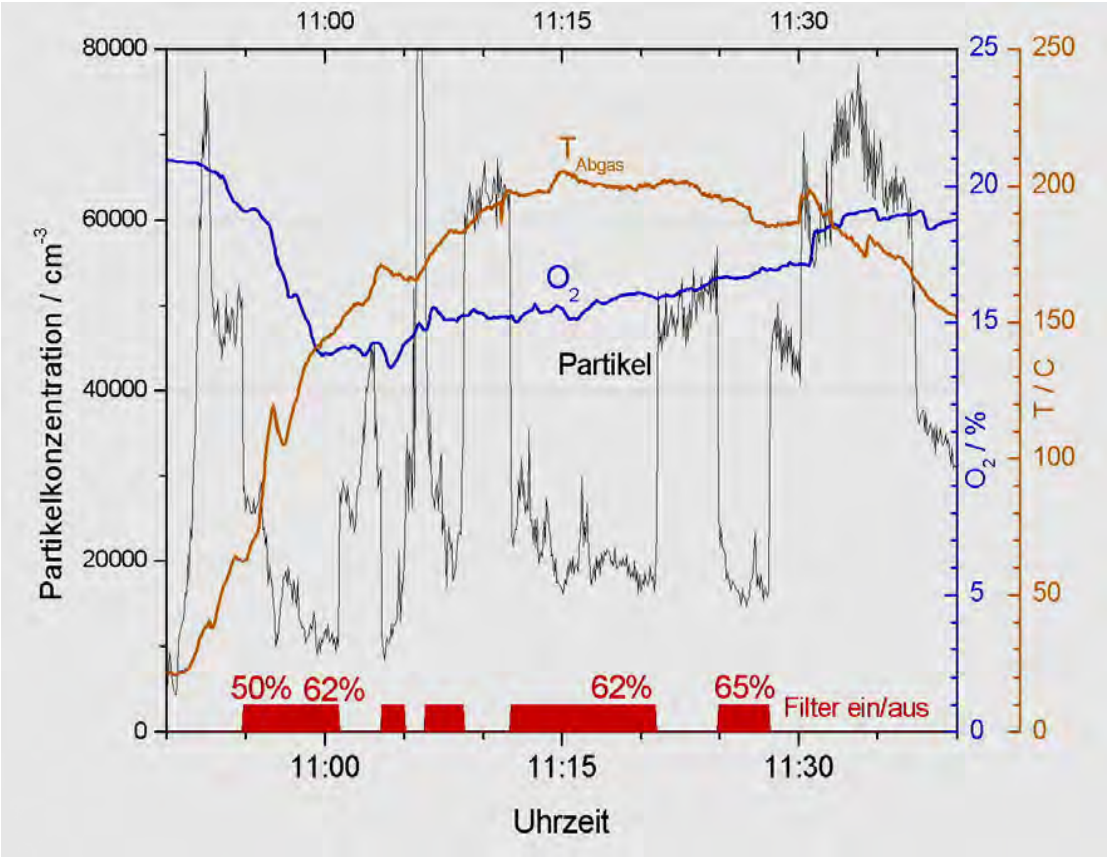
2004: log wood boiler, ~55% efficiency

2004: fireplace ~65% efficiency

experience under real life conditions
setup not yet optimised
short collection area
efficiency ~55%, deterioration ~5% after long operation

log wood boiler: Feb.-April 2004, 138h, ~2m/s, to 600°C
fireplace: Feb.-April 2004, 1600h, 530kg wood, to 500°C

Field tests

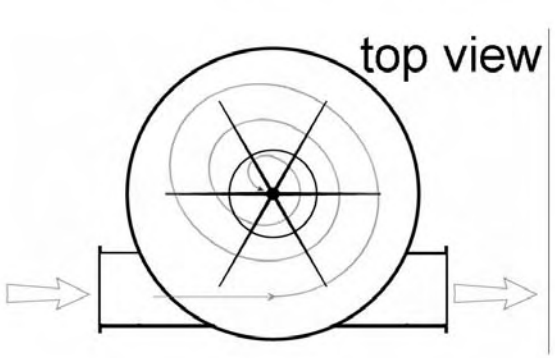

11:00
11:15
11:30
80000
60000
40000
20000
0
Partikelkonzentration / cm-3
25
20
15
5
0
O2 / %
250
200
150
100
50
0
T / C
TAbgas
O2
Partikel
50% 62%
62%
65%
Filter ein/aus
11:00
11:15
11:30
Uhrzeit

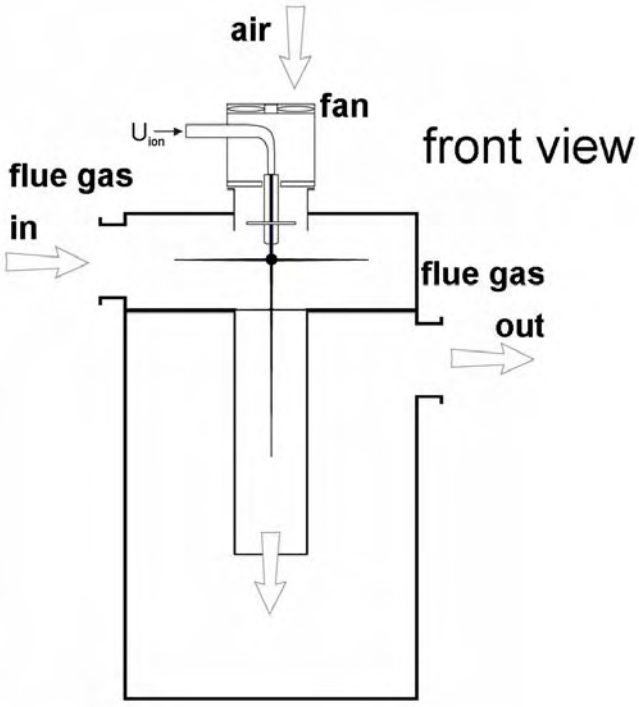
Field tests: Finished fireplace installation

Experience with setup und operation

- comfort
- functionality
- design
- reliabilty
- maintenance

ESP construction for small automatic appliance





Costs of the MiniPab system

estimated price

1000 to 1500 Euro

production costs of some key components
power supply: 100 €
case: *100.- €*
ESP module: *100.- €*
(incl. insulator & electrode)

Operation

power consumption
active: 10W
stand-by: 0 - 2W

no consumables

potentially reduced interval for chimney sweeper

Conclusions

- ✓ *Particle trap for small wood fired furnaces (single room)*
- ✓ ***good collection efficiency***
- ✓ ***cost effective***
- ✓ ***successful, real-life tests***

- ***preparation for series production***
- ***field test, pilot installations***
- ***small series***

The projects have been funded by BUWAL und BFE.

Outlook

Objective: Reduction of Particle Emissions

→ *Diesel wieder unterbieten!*

Adaptions for use in different types of appliances

→ *small automatic appliances*

→ *boilers*

Introduction of additional aftertreatment elements

→ *reduction of NOx, Smell*

Die Projekte wurden durch finanzielle Unterstützung durch BUWAL und BFE ermöglicht.