

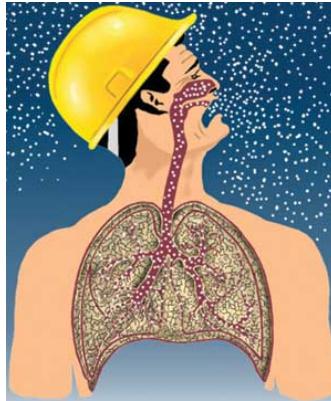


Adrian Hess :: Paul Scherrer Institut

# Size-Resolved Element Characterization of Aerosol Particles Emitted from Thermal Wood Treatment

20<sup>th</sup> ETH Conference on Combustion Generated Nanoparticles :: June 13-16, 2016

# Introduction



## Motivation: Characterization of aerosol particles

- Process gases
- ENP release  
(production and application)
- Nanomaterial and waste treatment
- Emission control  
(engines, turbines, incinerators)
- Human exposure
- Environmental aerosol studies

**Traditionally no size-resolved online element characterization available**

### 1991

Weber,  
Baltensperger et al.  
Paul Scherrer Institut

**Coupling of SMPS  
and ICP-AES**

### 2002-2013

SMPS – ICP-MS  
several couplings

**Specific applications**  
**Based on defined  
inlet flows**

### 2013-2015

Hess et al.  
Empa and PSI

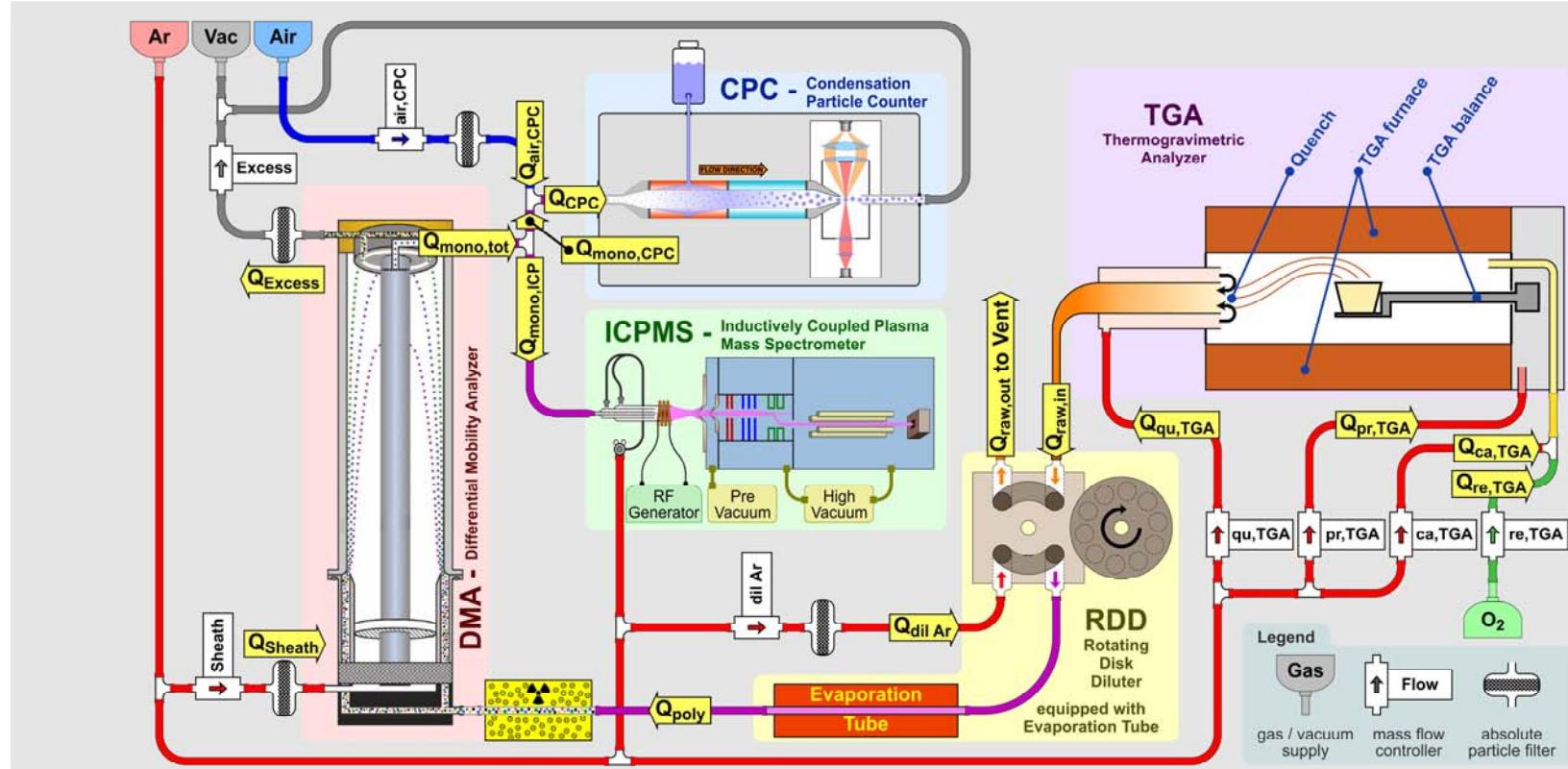
**RDD-SMPS-ICPMS**  
**Idea: Versatile real  
aerosol instrument**

### 2015-2016

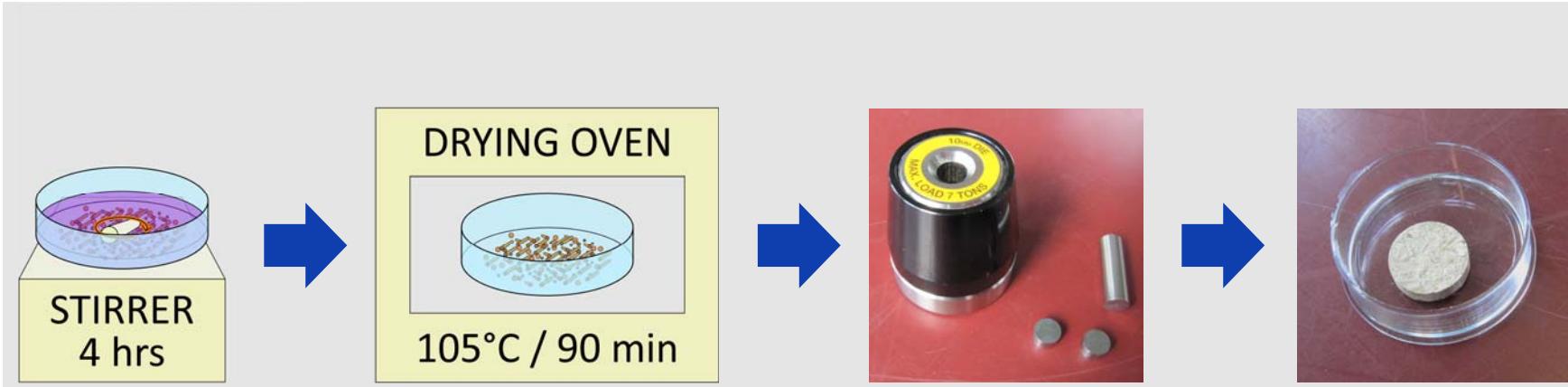
Hess et al.  
Paul Scherrer Institut

**Biomass emissions**  
**Time / size resolved  
element analysis**

# Instrumental Arrangement



# Sample Preparation



Typ. 30 ppm Cu  
in waste wood

→ no Cu signal

## Impregnation:

100 times more:

→ 0.3 % Cu

**2 g impregnated  
sawdust batches**

- KCl
- $\text{CuSO}_4$
- $\text{CuCl}_2$
- $\text{CuSO}_4\text{-KCl}$

**200 mg into die**

$$F = 60 \text{ kN}$$

$$t = 1 \text{ min}$$

**Impregnated  
sawdust pellets**

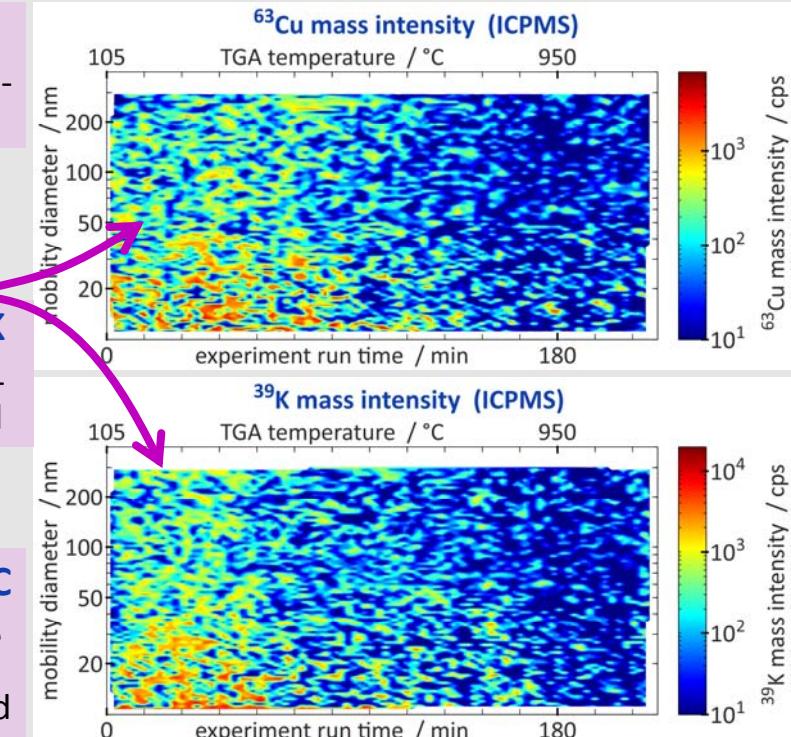
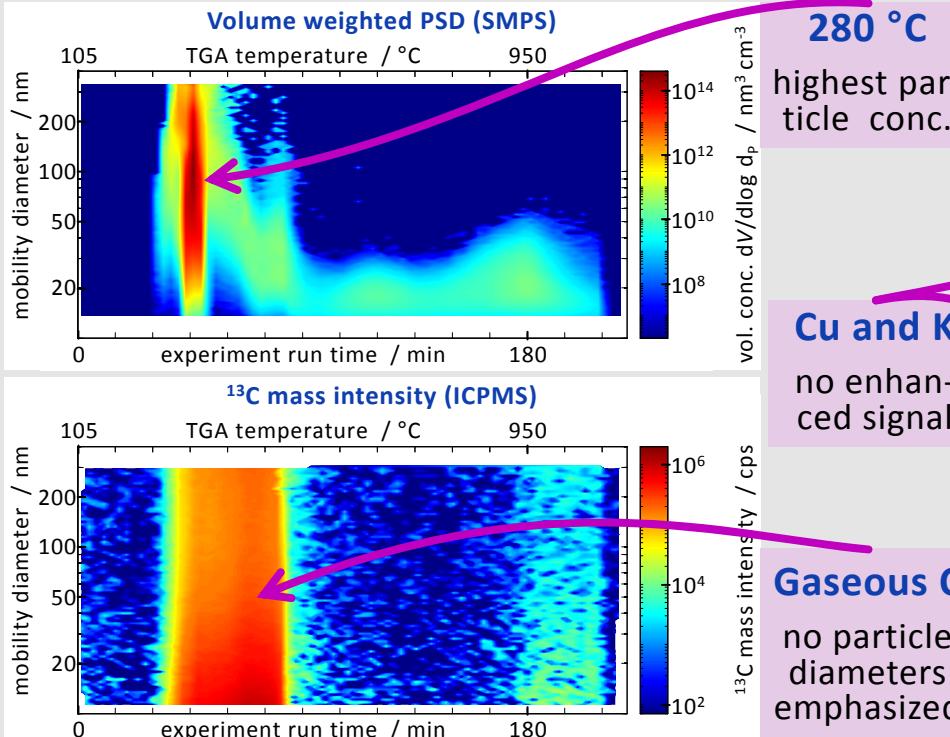
$$\varnothing = 10 \text{ mm}$$

$$d \approx 2.5 \text{ mm}$$

$$m \approx 200 \text{ mg}$$

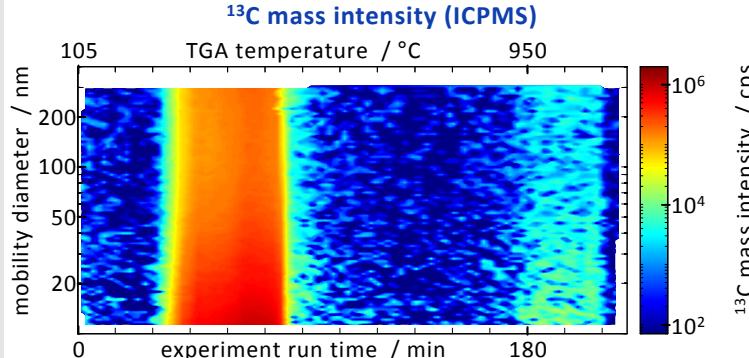
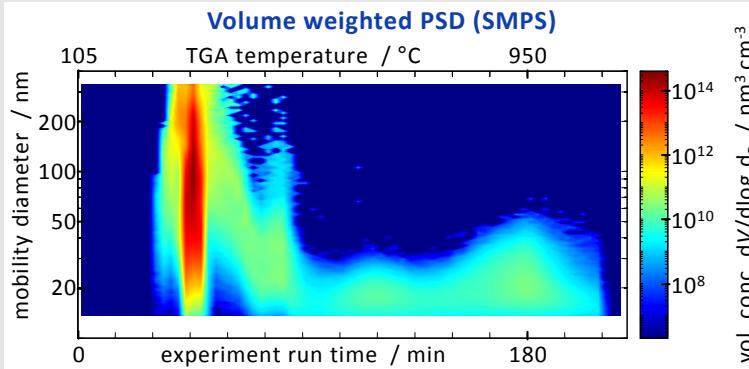
# Measuring Results

## Non-treated sawdust

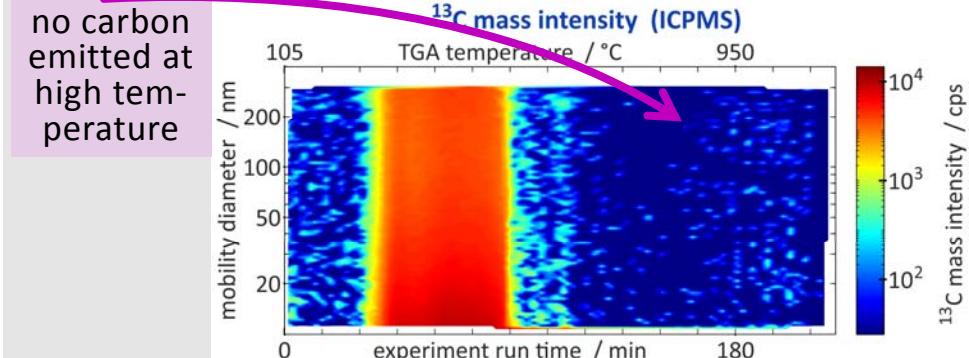
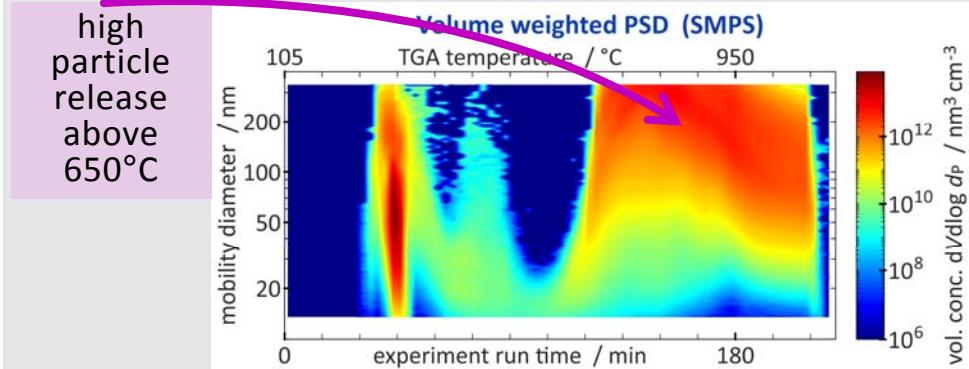


# Measuring Results

## Non-treated sawdust

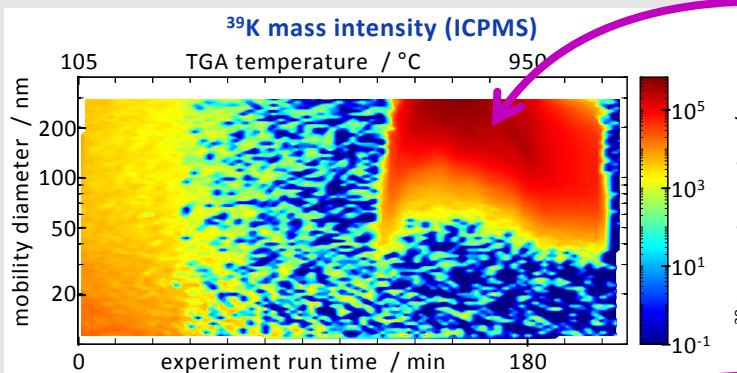


## KCl impregnated sawdust

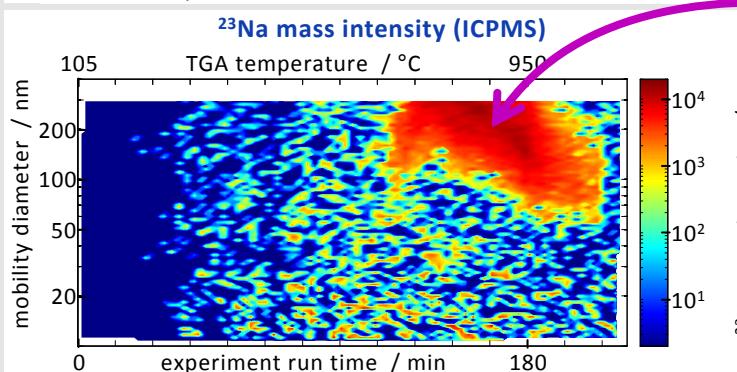
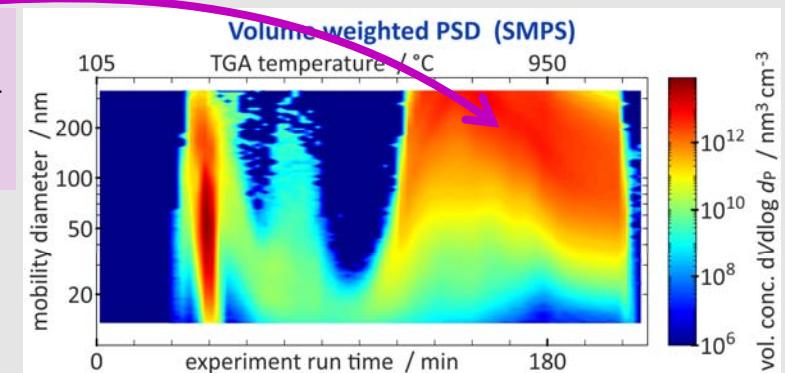


# Measuring Results

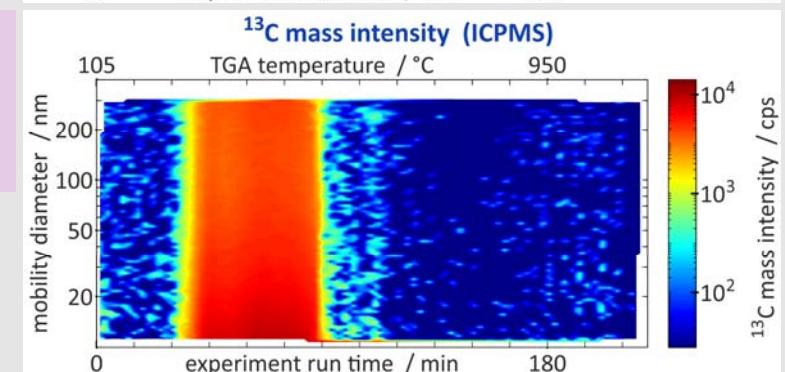
## KCl impregnated sawdust



**Potassium**  
clear coincidence with SMPS signal

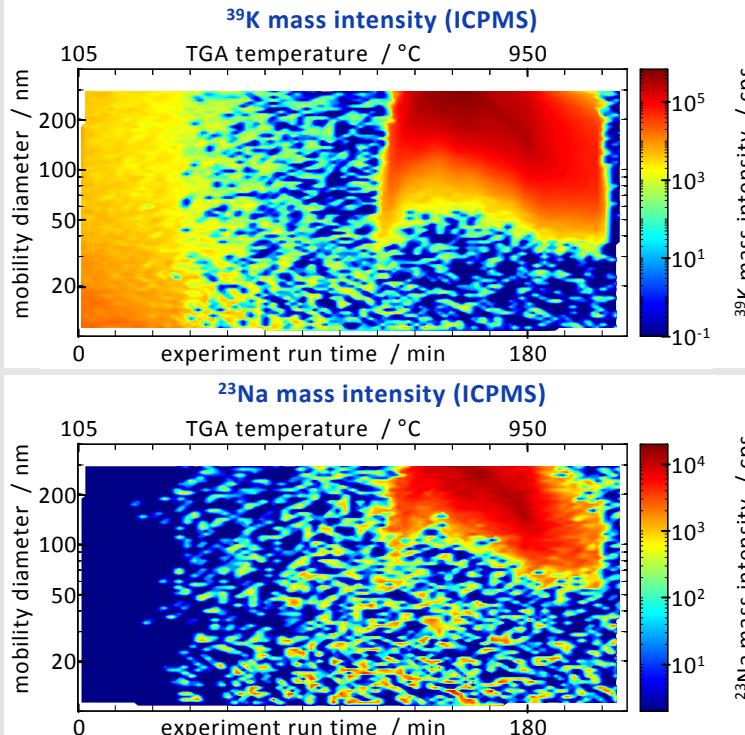


**Sodium**  
mobilized by  $\text{Cl}^-$  ions from KCl



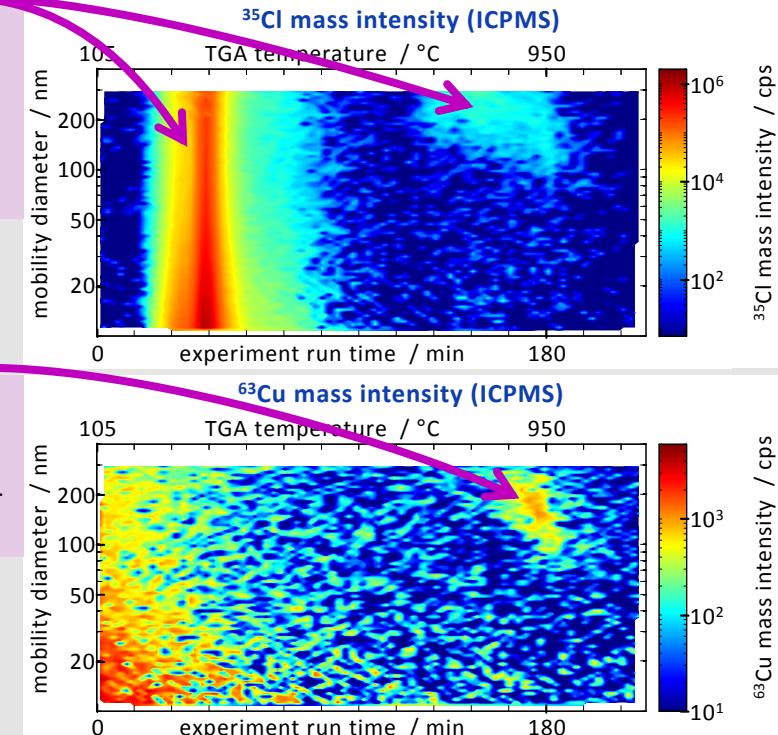
# Measuring Results

## KCl impregnated sawdust



## Chlorine

gaseous (HCl) and particulate (salts) Cl

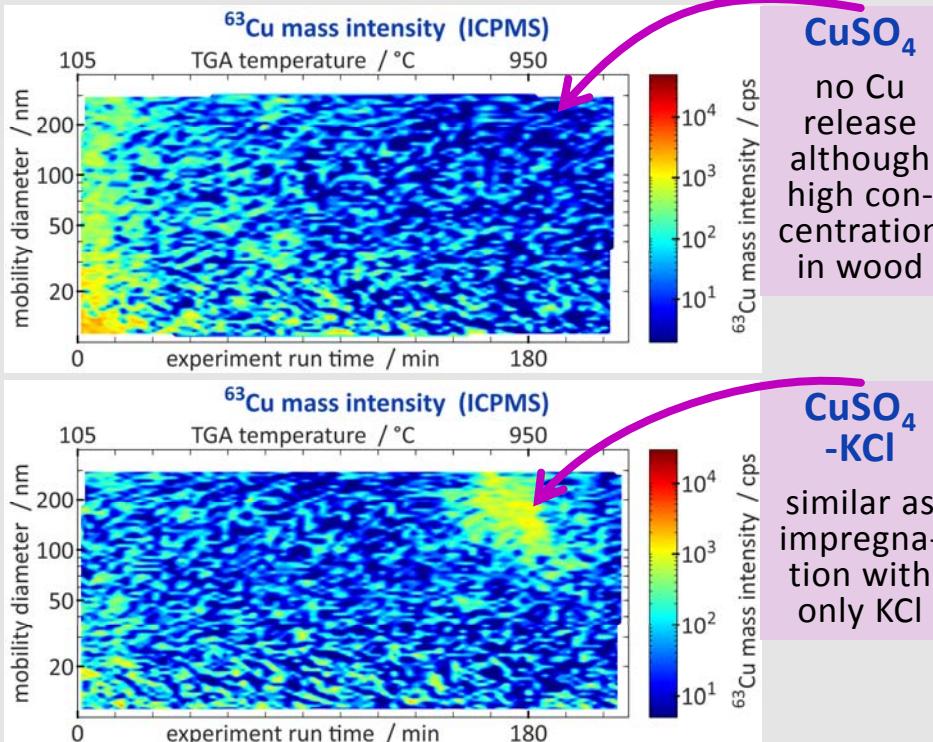


## Copper

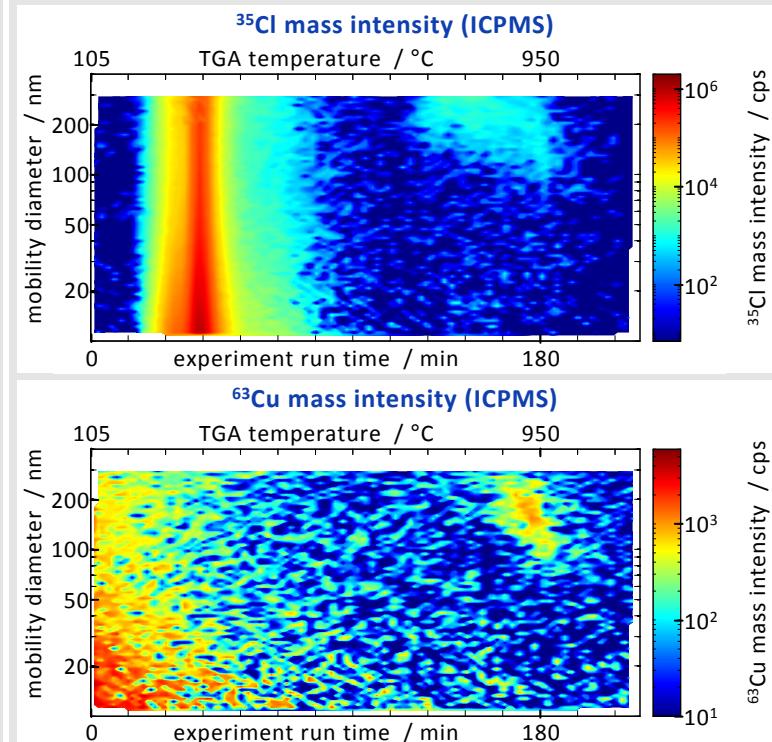
mobilized by KCl impregnation

# Measuring Results

## Copper impregnations



## KCl impregnated sawdust



# Conclusion

## Application

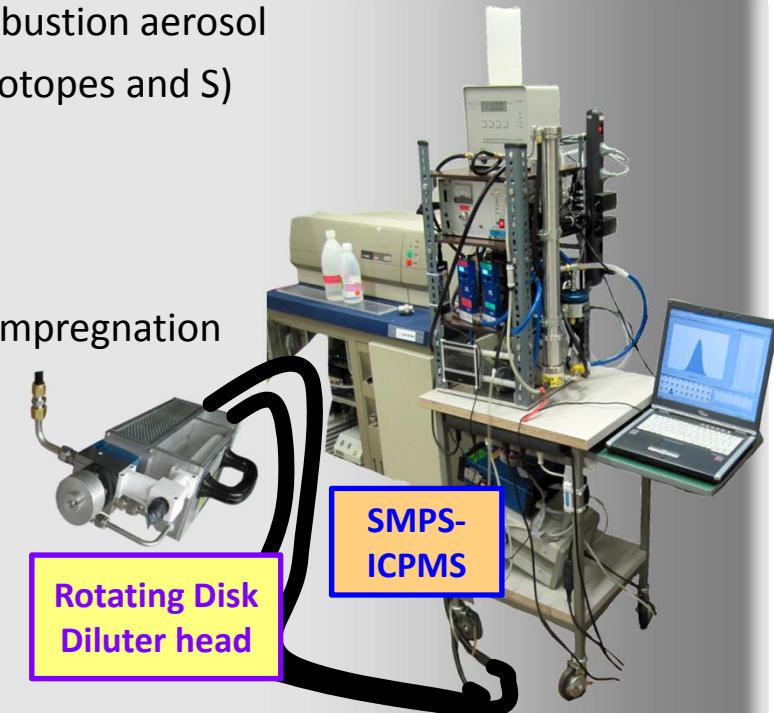
- RDD allows SMPS-ICPMS application for biomass combustion aerosol
- Detected elements: Alkali metals, Cu, Cl (also other isotopes and S)
- TGA: Reproducible experiment conditions (O<sub>2</sub> content, furnace temperature, gas flows)

## Experiment results

- Cu release dominated by KCl and not CuSO<sub>4</sub> or CuCl<sub>2</sub> impregnation
- Cl<sup>-</sup> ions added to the fuel provoke the release of alkali and heavy metals

## Element map diagrams

- Time-resolved size and element analysis of gas-borne nanoparticles
- Gaseous and particulate matter visually distinguished



# Outlook

## Data processing

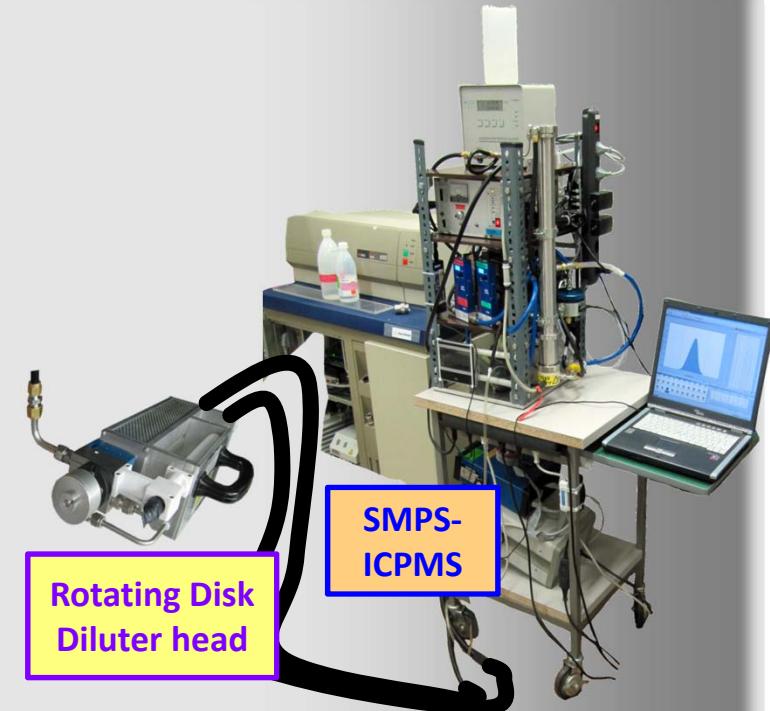
- Implement correction for multiple particle charges
- Establish calibration for detected elements  
→ quantitative measurements  
i.e. mass concentration instead of intensity

## Technical adaptions

- Mobile installation in container → leave the lab
- Other instrument configurations  
e.g. sheath gas recirculation  
e.g. air operated DMA and gas exchange device

## Applications

- Engines on test bench (diesel and aircraft engines)
- Behavior of particles in waste incineration





## Acknowledgements

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