VI-ACI: Work Package L3
- Laboratory Experiments at ETH Zurich -
CCN – IN – Hygroscopicity – Aerosol-MS

Olaf Stetzer, Ulrike Lohmann, Daniel Cziczo

ETH Zurich, Switzerland
Institute for Atmospheric and Climate Science
IAC*ETH*

VI-ACI – Kickoff-Meeting - Karlsruhe - 14/15.05.2007

Overview

<u>CCN – warm clouds:</u>

- Does size matter or chemistry?
- Hygroscopicity and chemical composition

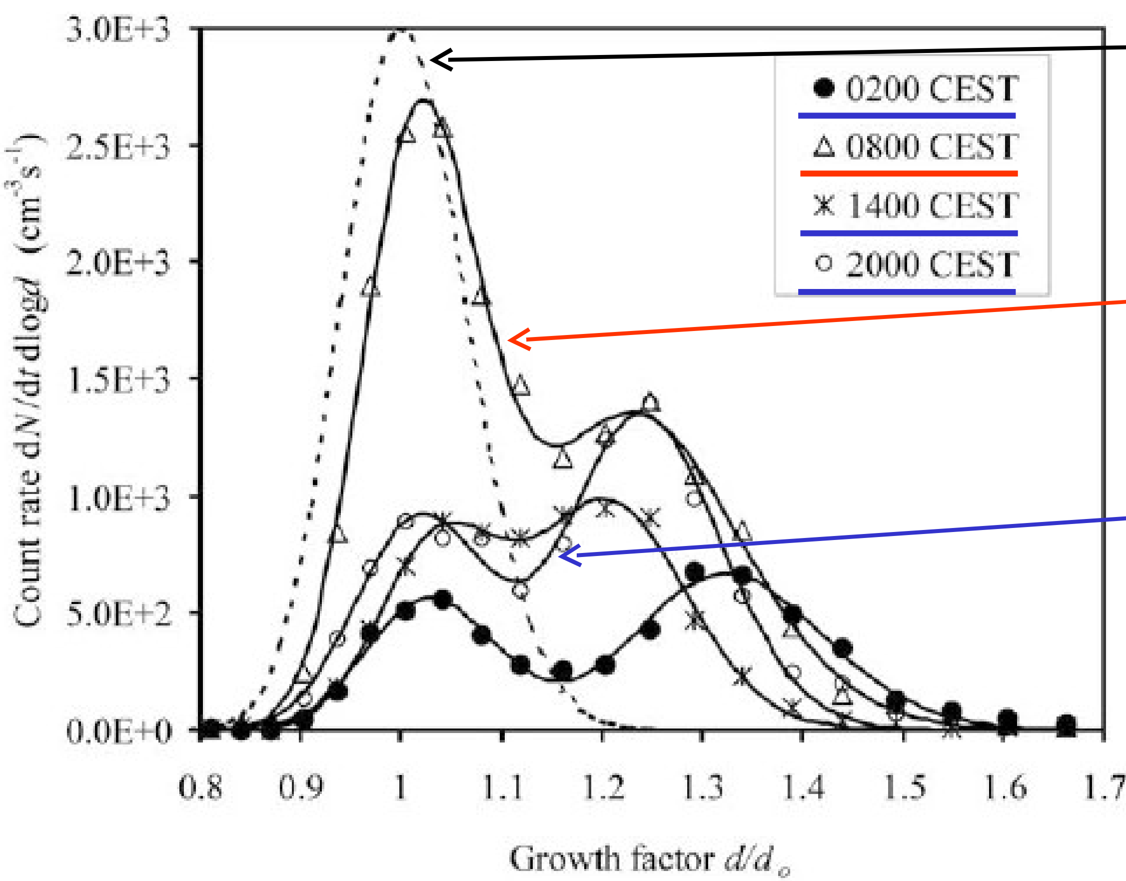
<u>IN – mixed phase and cold clouds:</u>

- Which modes of IN are important?
- Chemical „features“ of good IN

- Summary

CCN – warm clouds

Atmospheric Effects : Milan



Initial Aerosol Size

'Rush Hour' = mainly soot

Other times = mixed

Inferred, not know!

Figure 6. Temporal evolution of the growth factor (d/d_0) distribution on 2 June 1998 during IOP 2. Dry monodisperse particles (d_0 = 100 nm, dashed line) were exposed to RH = 90% at 0200, 0800, 1400, and 2000 CEST (points). The solid lines are bimodal fits of the less and more hygroscopic modes. *Y* axis units correspond to CPC counts normalized to both the diameter interval and the scan time during such an interval. Lines denote a monomodal/bimodal lognormal fit.

Baltensperger, JGR, 2002.

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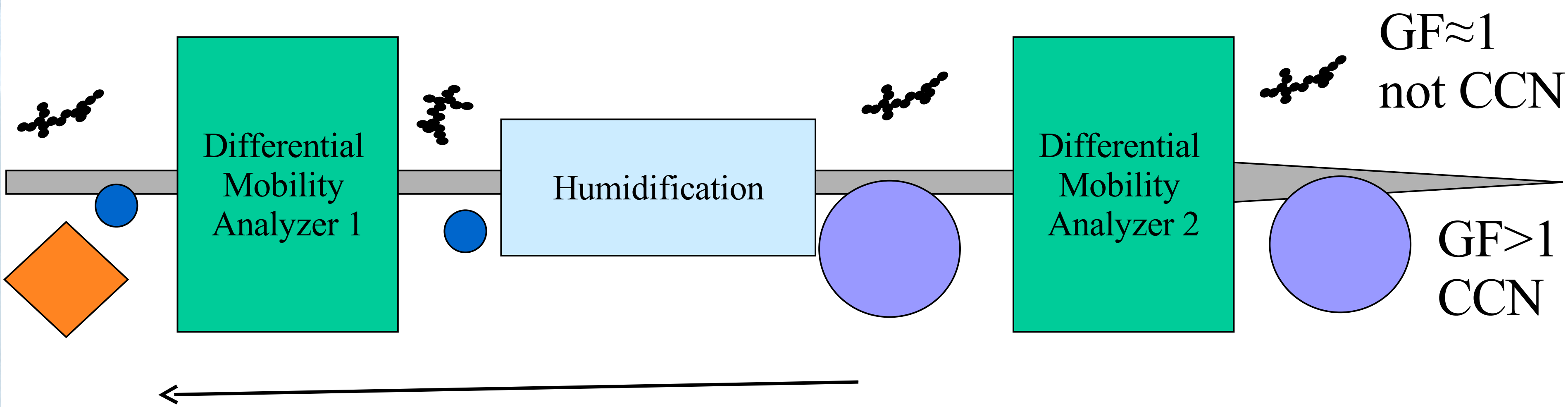
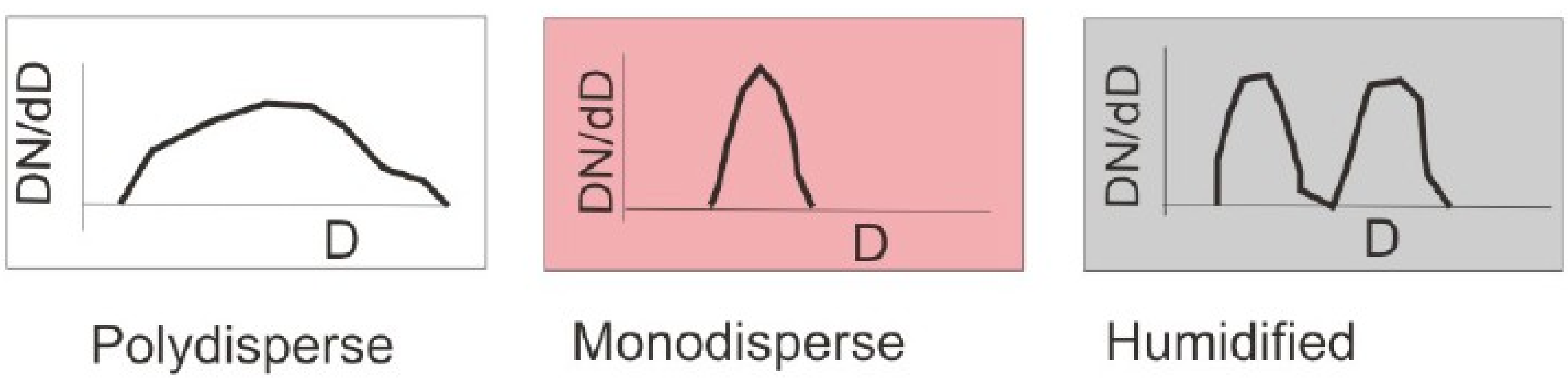
CCN – warm clouds

Experimental Setup:
Hygroscopisity Tandem DMA (HTDMA)





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Past Studies:

Examples of measurement results of GF (RH=85-90%)

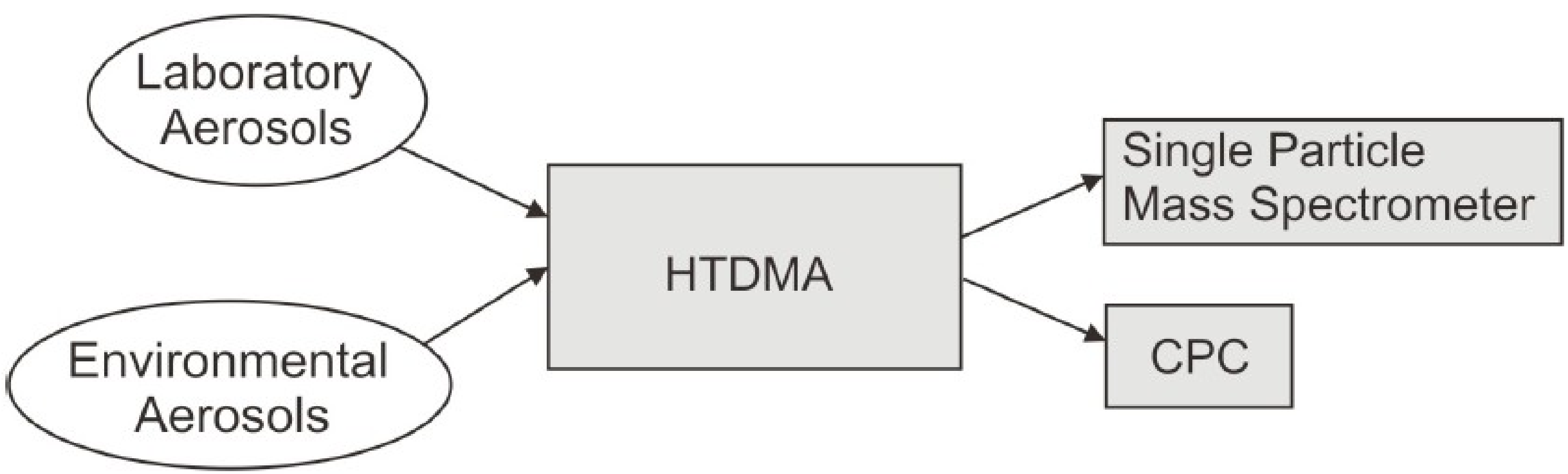
Location	GF	Group
Milan	1.1 and 1.2-1.5	Baltensperger et al., 2002
Jungfraujoch	1.1-1.3	Weingartner et al., 2002
Izana, Tenerife	1.15, 1.40 and 1.61	Swietlicki et al, 2000
Kleiner Feldberg	1.05 and 1.36	Svenningsson et al., 1994
Munich	1.0 and 1.3	Ferron et al., 1994

Determination of particle chemical composition:

HTDMA and ...	Group	Limitation
Impactor	Pitchford & McMurry, 1994	parallel
Electron Microscopy	McMurry et al., 1996	parallel
SPLAT-MS	Buzorius et al., 2002	laboratory

CCN – warm clouds

Chemical Composition of CCN?
→ Coupling HTDMA with Single-Particle-Mass-Spectrometry



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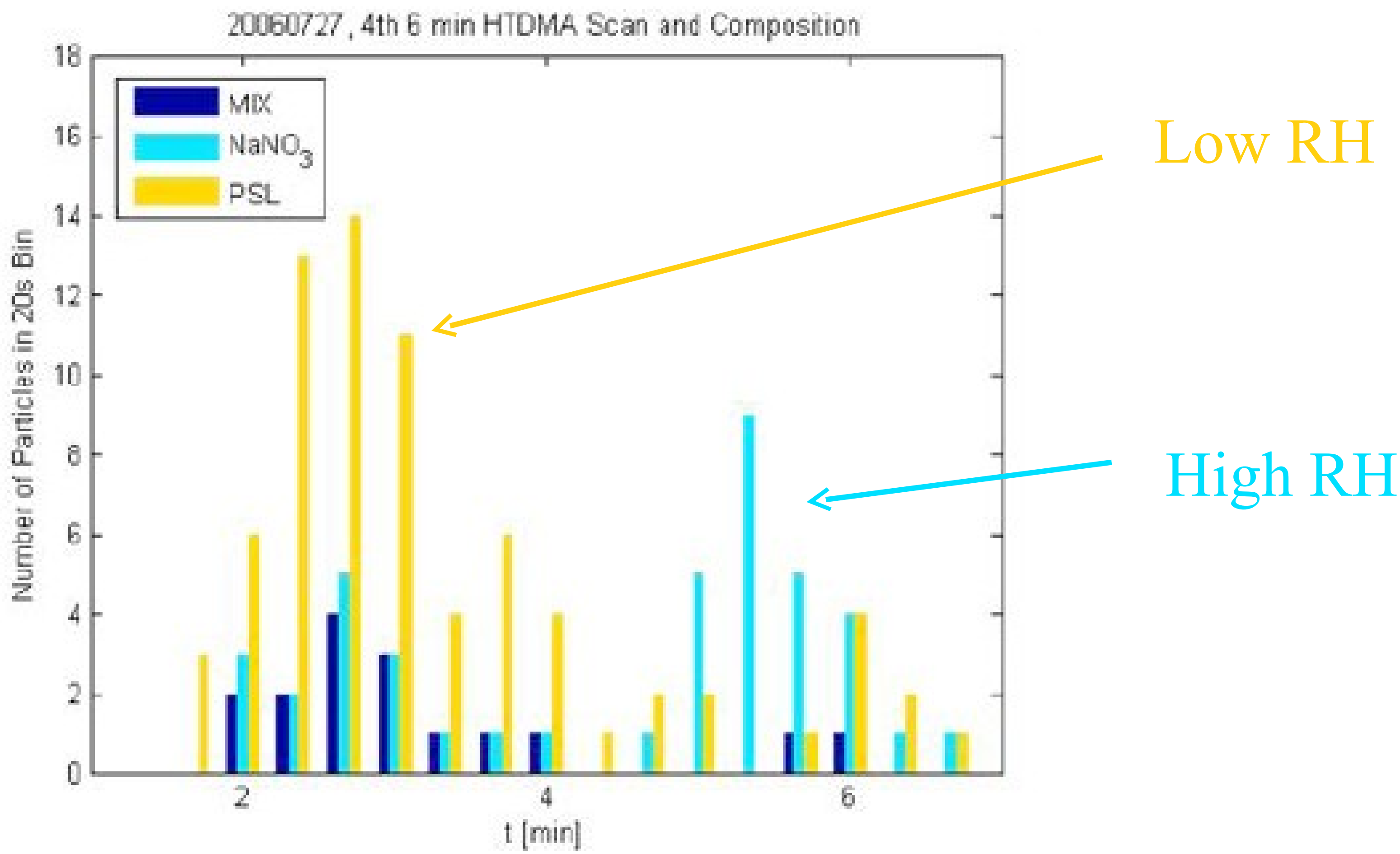
CCN – warm clouds

HTDMA combined with Mass Spec: Proof of Concept?



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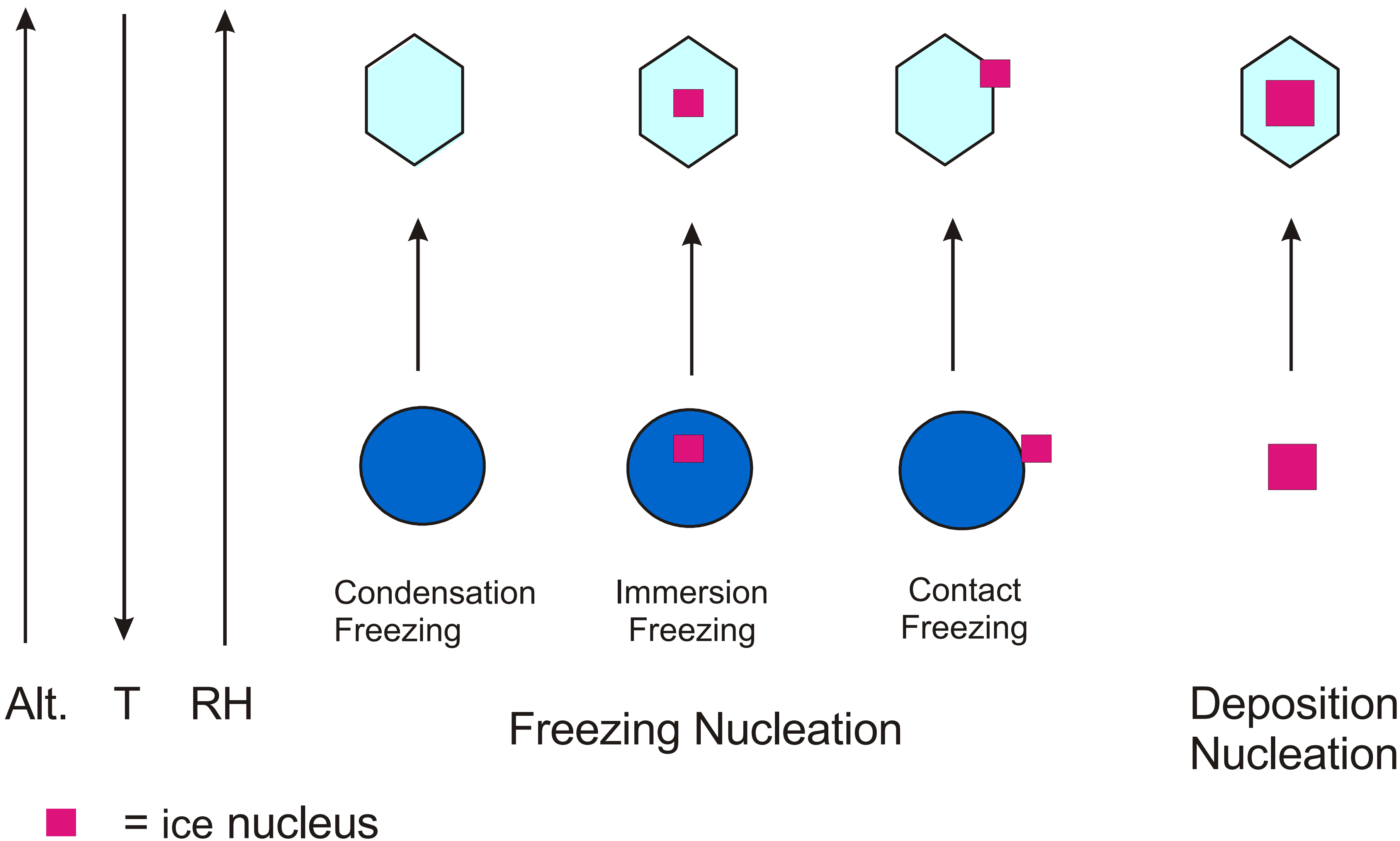
IN – mixed phase and cold clouds



Modes of Ice Nucleation (Vali, 1985)

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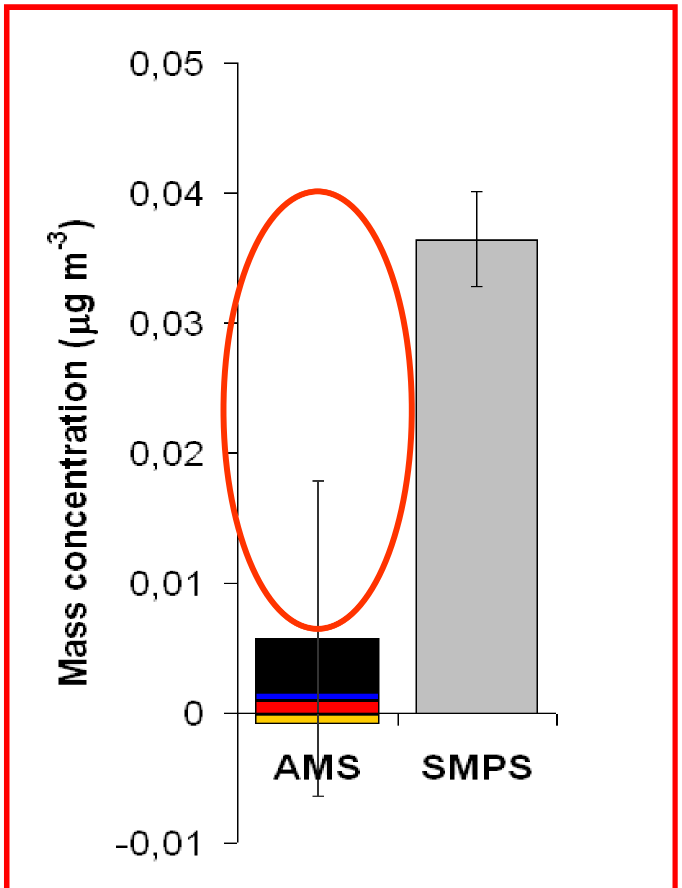
IN – mixed phase and cold clouds

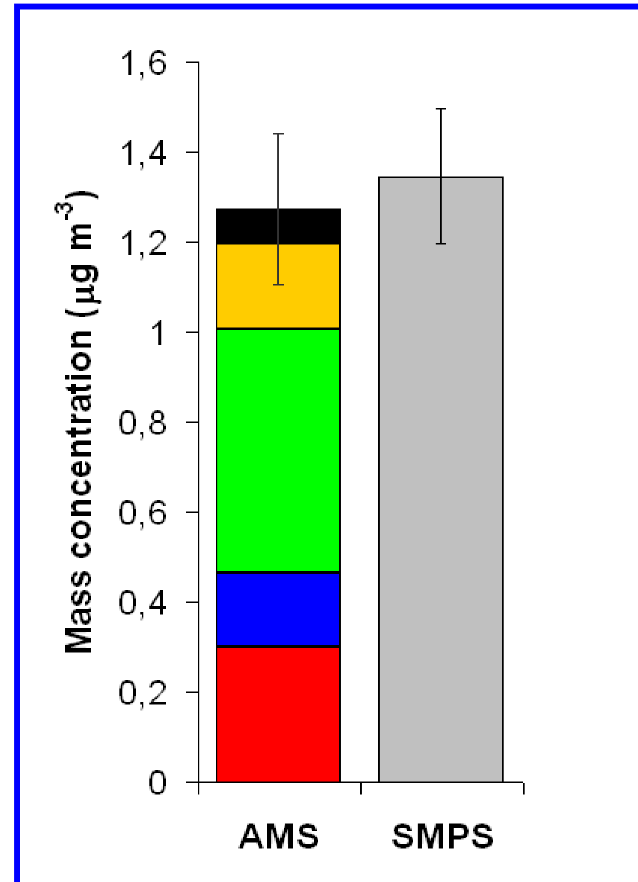
What is the Aerosol and IN Composition ?

Ice Residue



Ammonium
Organics
Nitrate
Sulphate
BC

Total



- Composite from AMS (volatile components) and BC (EC/soot) measurements.
- Lack of ‘closure’ between the volatile components + BC and ice residue.

What are the missing ice forming aerosols?

Courtesy of J. Schneider and S. Walter

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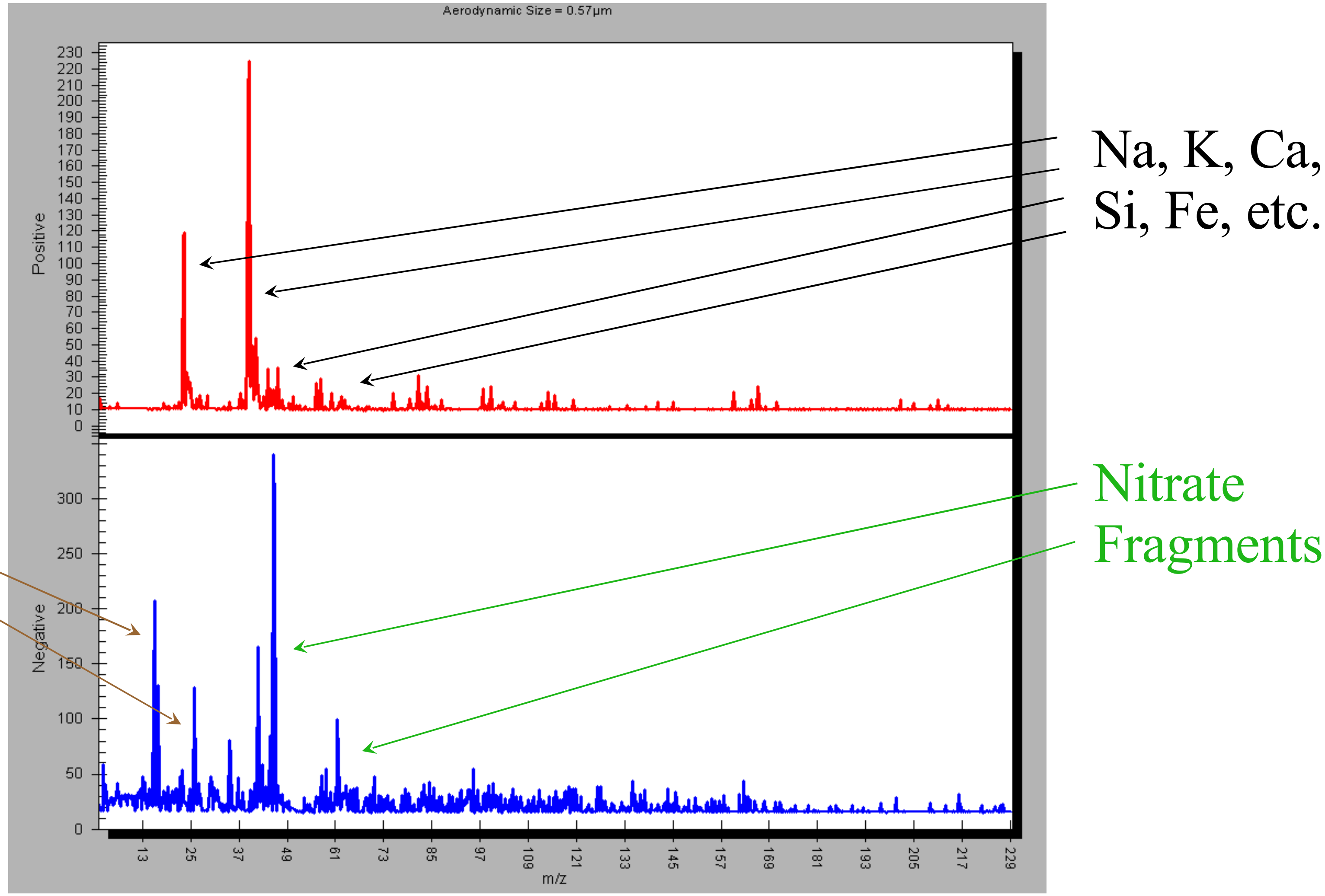
2007 Ice Residuals – Jungfraujoch – measured with ATOFMS



- Composition consistent with mineral dust which has uptaken some nitrate (see work of Grassian, Laskin, and others)
- No significant sulfate

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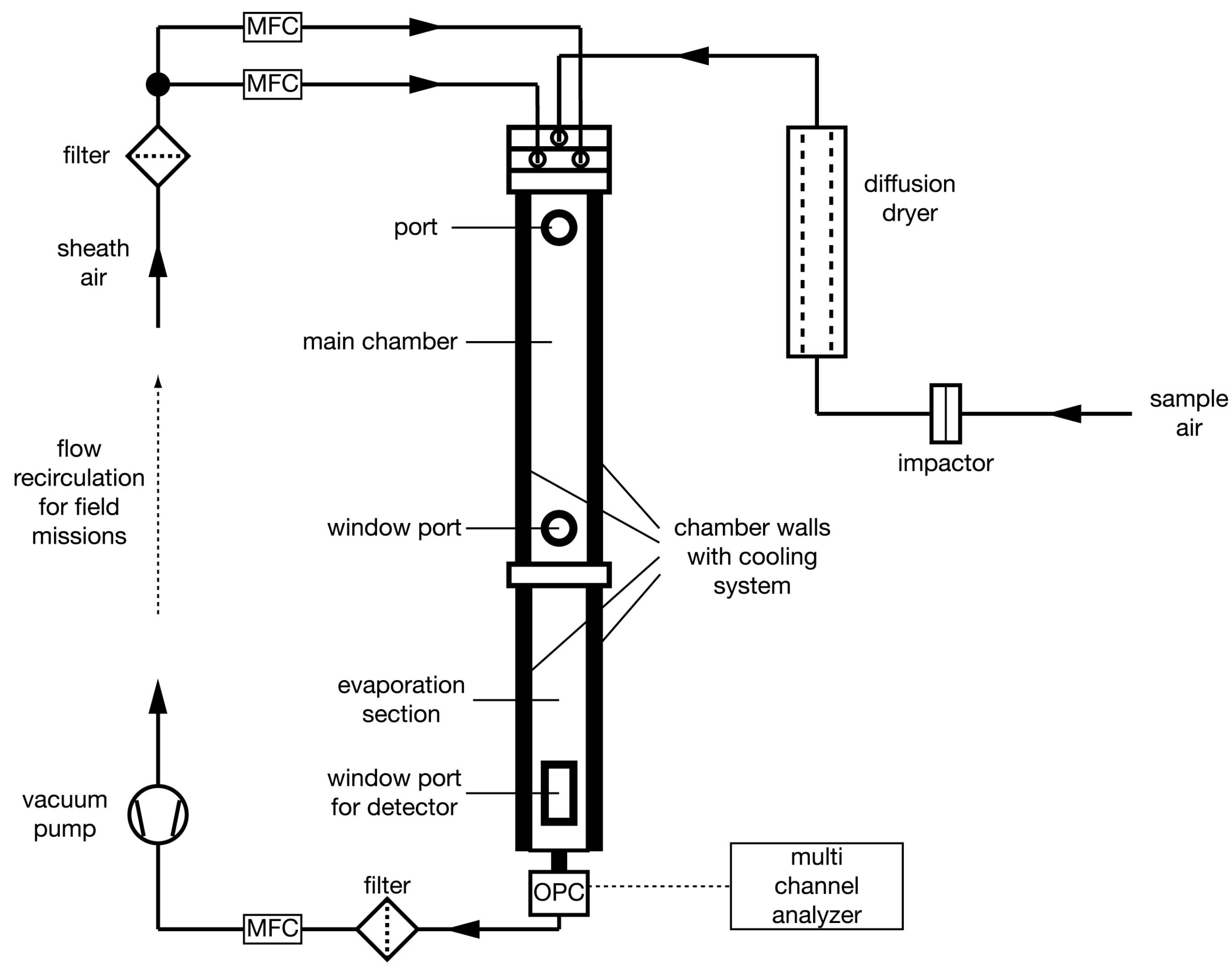
IN – mixed phase and cold clouds

The Zurich Ice Nucleation Chamber (ZINC) and its portable version PINC will be used for ice nucleation studies at ETH Zurich.



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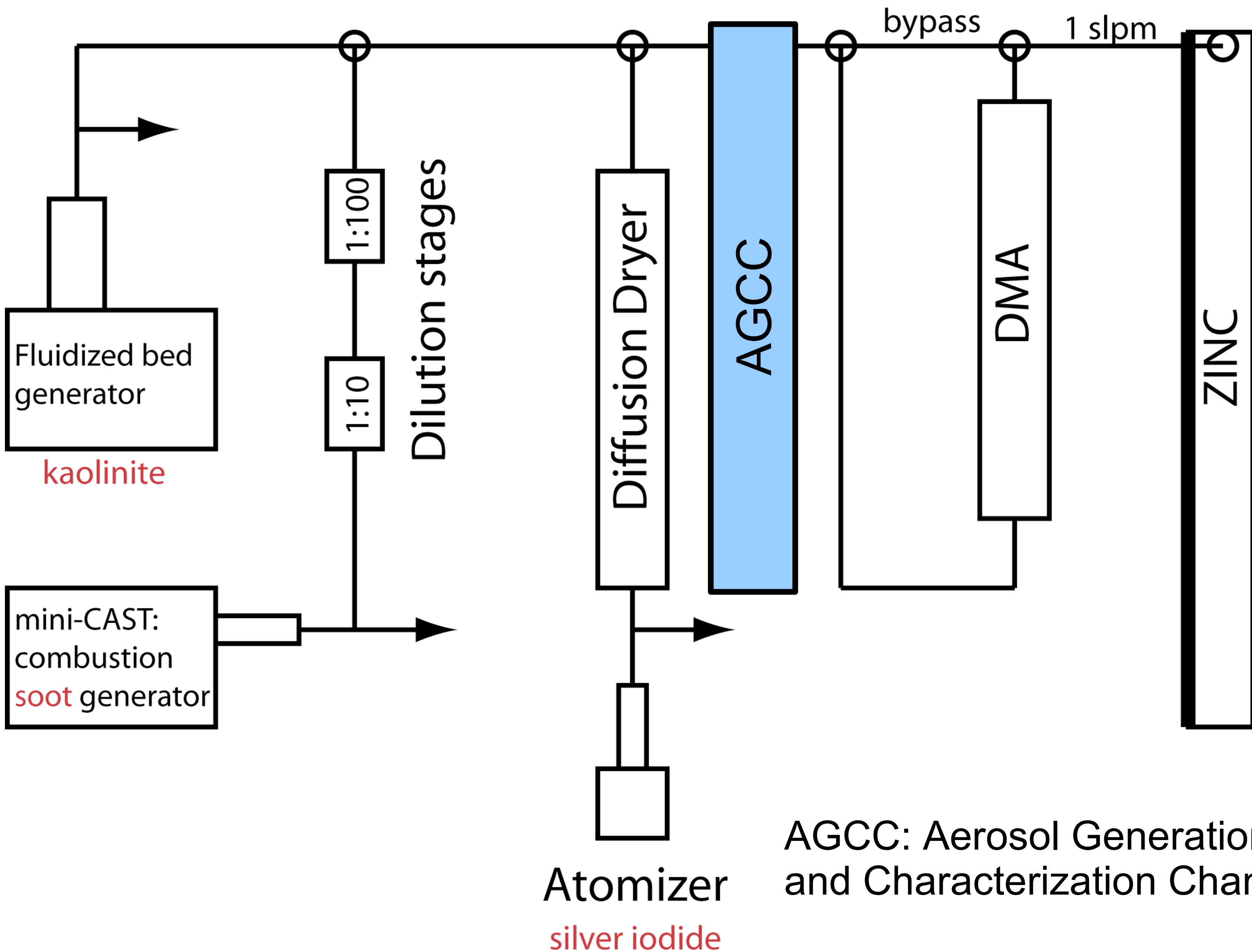
Setup for lab experiments with silver iodide, kaolinite and (soot)



AGCC: Aerosol Generation and Characterization Chamber

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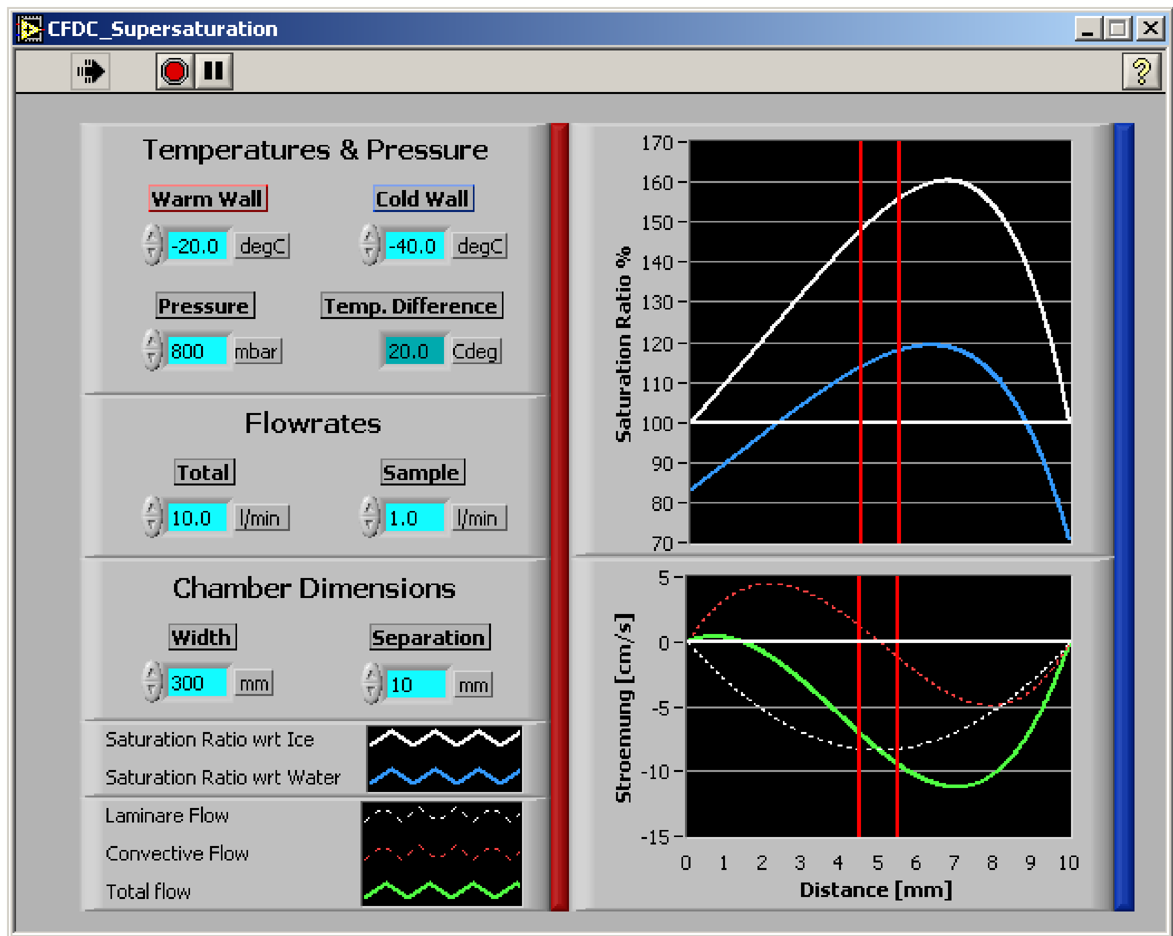
Temperature and saturation ratio profiles in the ZINC/PINC instruments:

Both walls are held at different temperatures and are covered with ice.
Linear profiles in absolute water vapour pressure and temperature develop.
Because of the Clausius-Clapeyron-Law a supersaturation wrt ice exists in the chamber and peaks roughly at the same position where the aerosols are injected.



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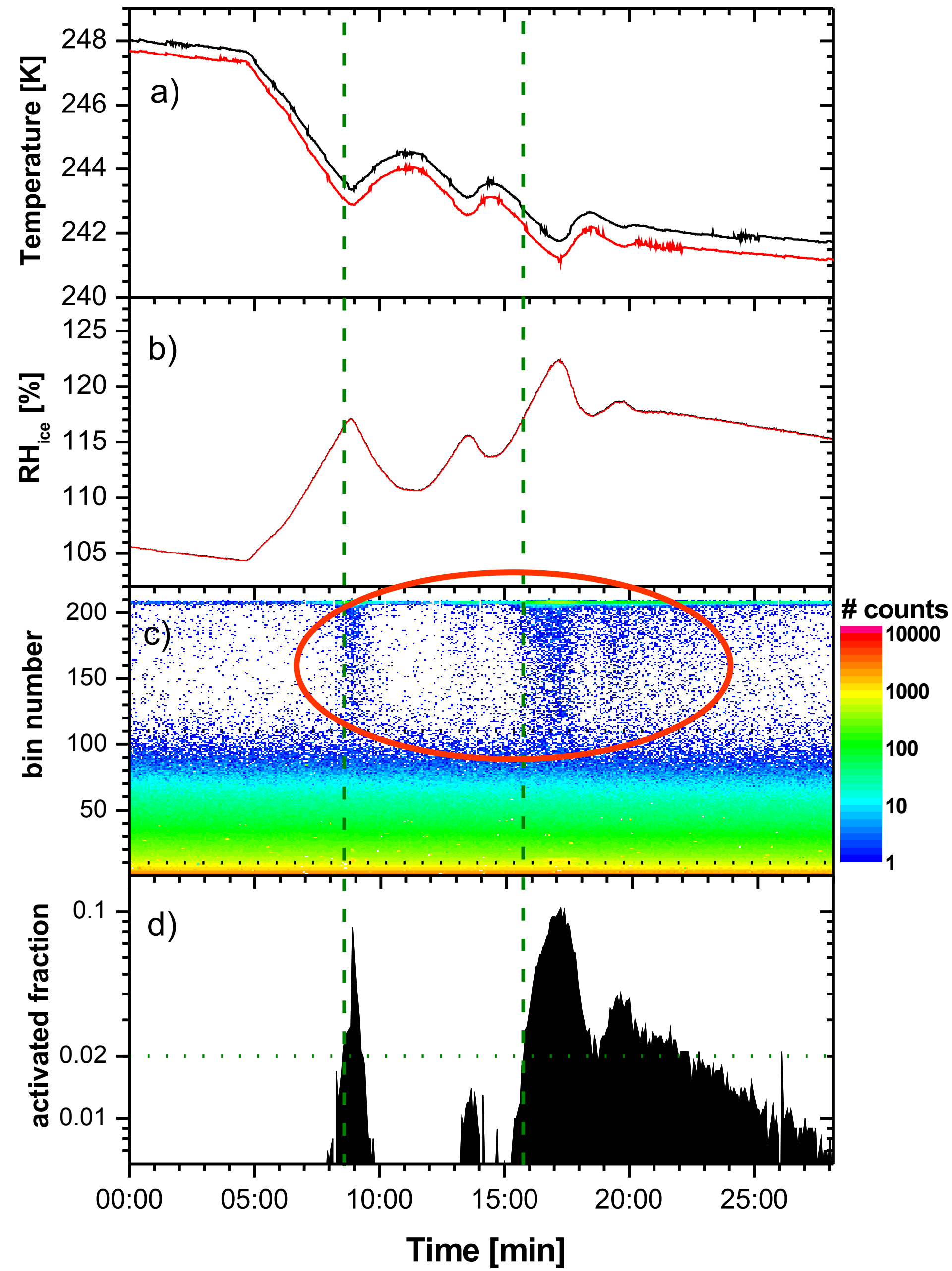
Proof of concept and validation experiments with AgI aerosols:

AgI particles were produced by atomizing an aqueous suspension.

Temperatures of cold and warm walls were varied to scan through different sample temperatures (panel a) and supersaturations (panel b).

Particle size spectra were recorded (panel c) and integrated to get the fraction of activated particles (panel d) as function of T and RHi.

Activation threshold was set to 2 %.



Stetzer et al., Aerosol Science & Technology 2007, submitted

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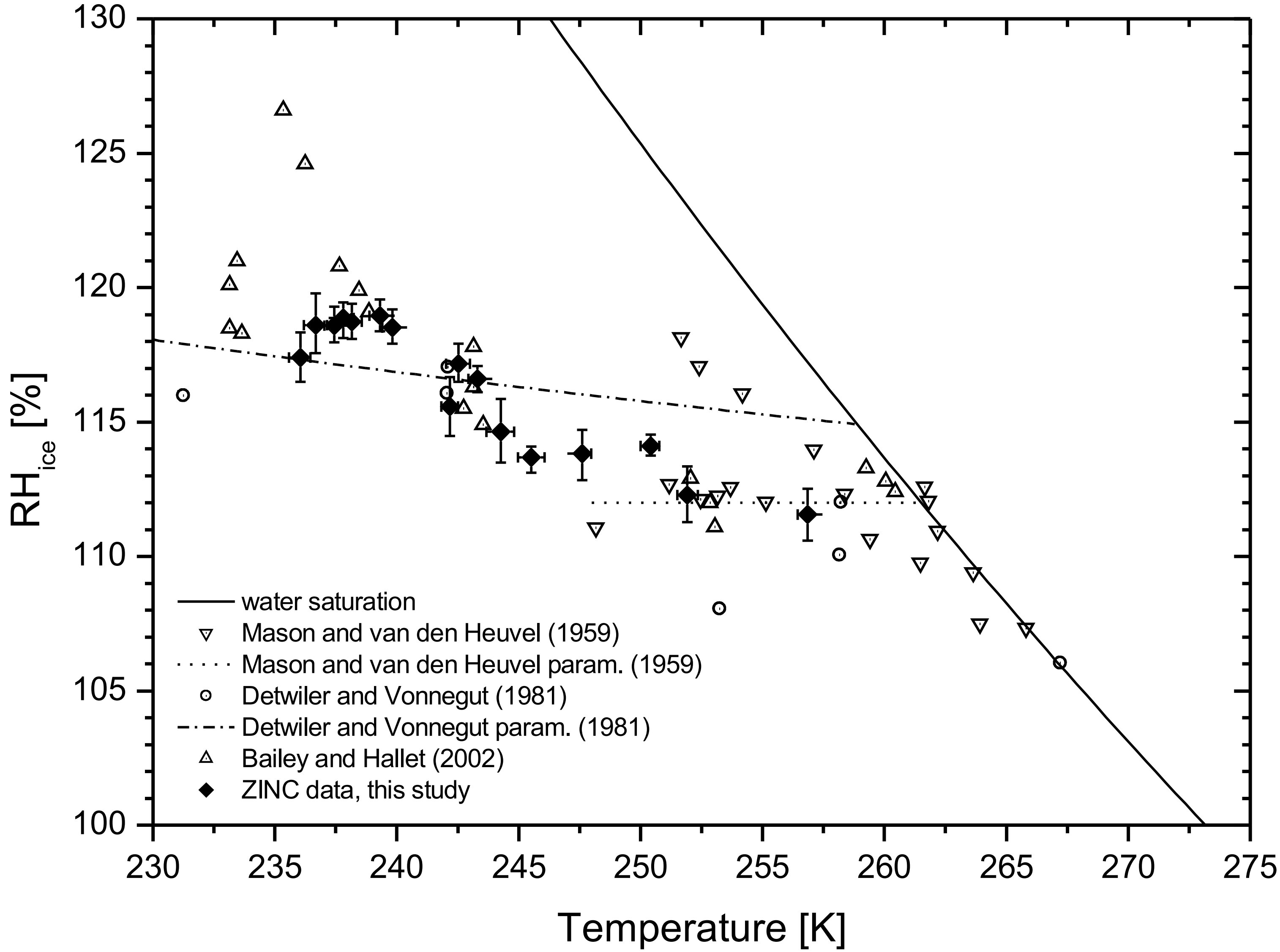
Comparison of ZINC data for AgI activations with different literature data.



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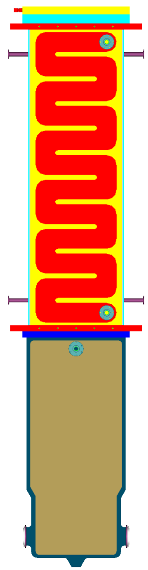
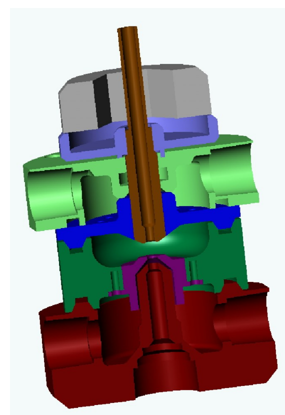
Mass Spectrometry of Ice Forming Aerosols

ZINC (CFDC)



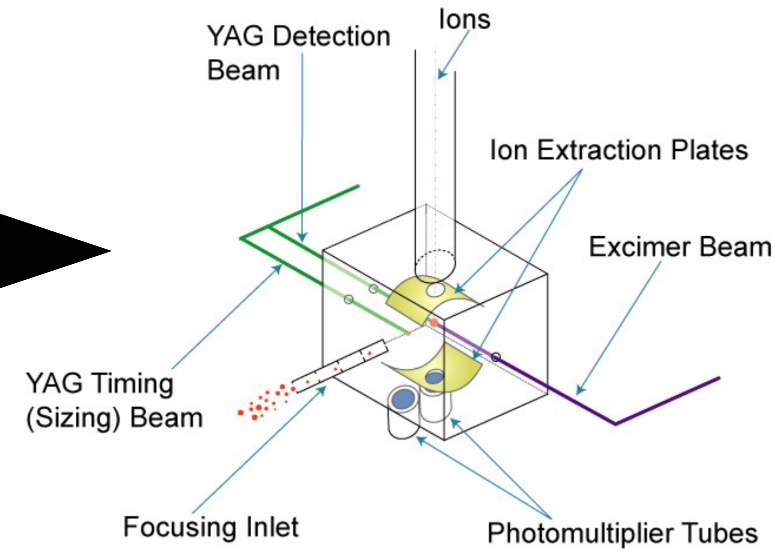
Ice Formation

LCVI



Inertial Separation

Mass Spec



PALMS or TSI ATOFMS

Combination of CFDC
+ LCVI
+ Mass Spec
has been used before
on Storm Peak (Colorado)

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Summary

CCN – warm clouds:

- Aerosols with different growth factors (GF) have been observed in field studies
- A relationship between GF and chemical composition was only inferred but not directly measured
- A combination of HTDMA (PSI) and Aerosol Mass Spec (ETH) will be used for direct closure of GF and chemistry

IN – mixed phase and cold clouds:

- ZINC instrument for IN activation experiments available
- ZINC was tested and validated with AgI particles against literature data
- A LCVI will be used to separate activated ice crystals behind the ZINC instrument
- These particles will be directed to single particle aerosol MS to obtain chemical composition of individual IN

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