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

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# Overview

**Experimental activities at ETH Zurich related to VI-ACI Work Package L3:**

- Ice Nucleation studies with ZINC (ICIS results)
- Immersion freezing studies
- Ice Particle Imaging at AIDA with our Holographic Microscope
- CCNC – Mass Spec (ATOFMS) coupling
- Summary

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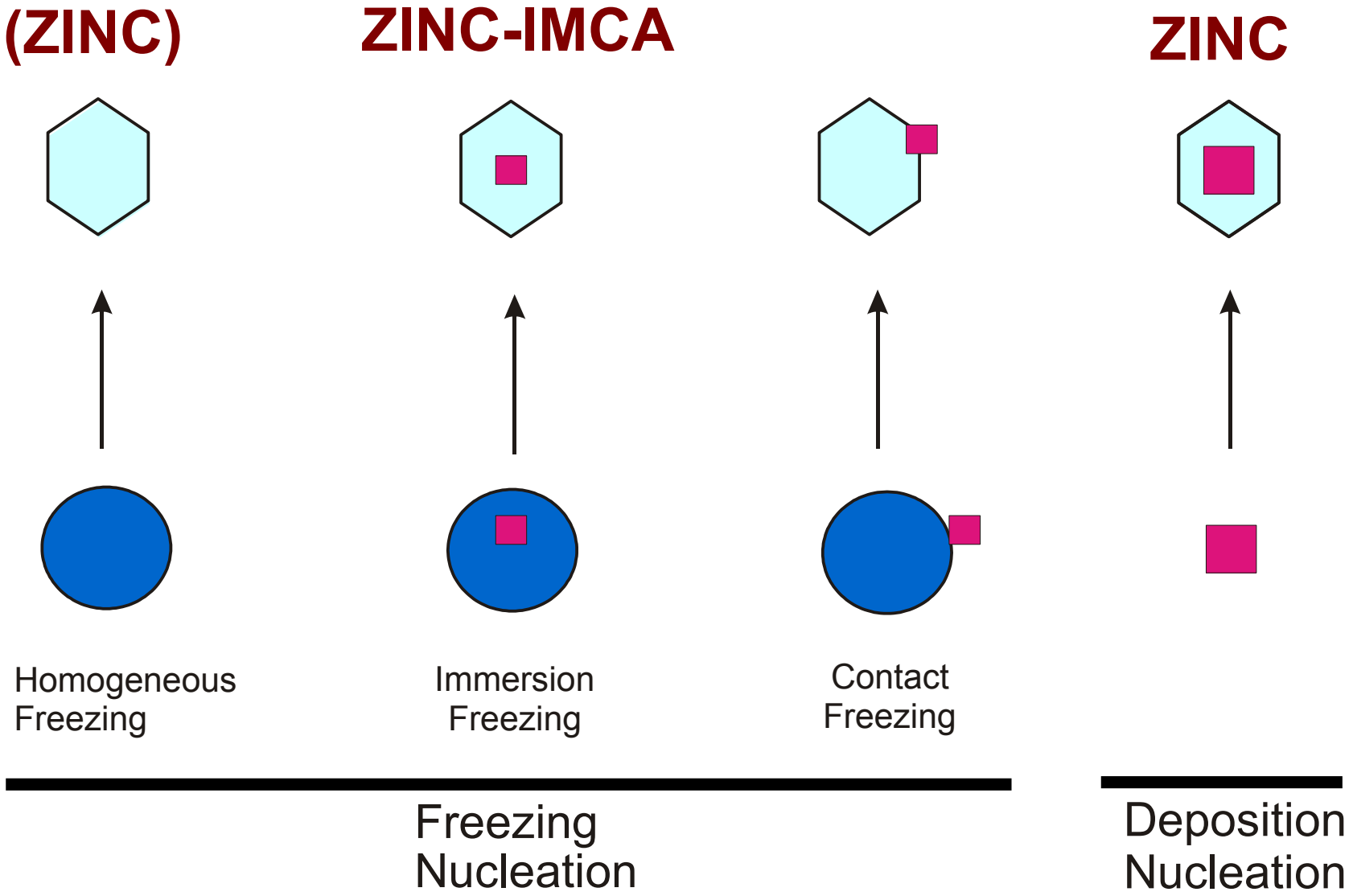
# IN – mixed phase and cold clouds




= ice nucleus

Modes of Ice Nucleation (Vali, 1985)

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# Design concept of ZINC/PINC

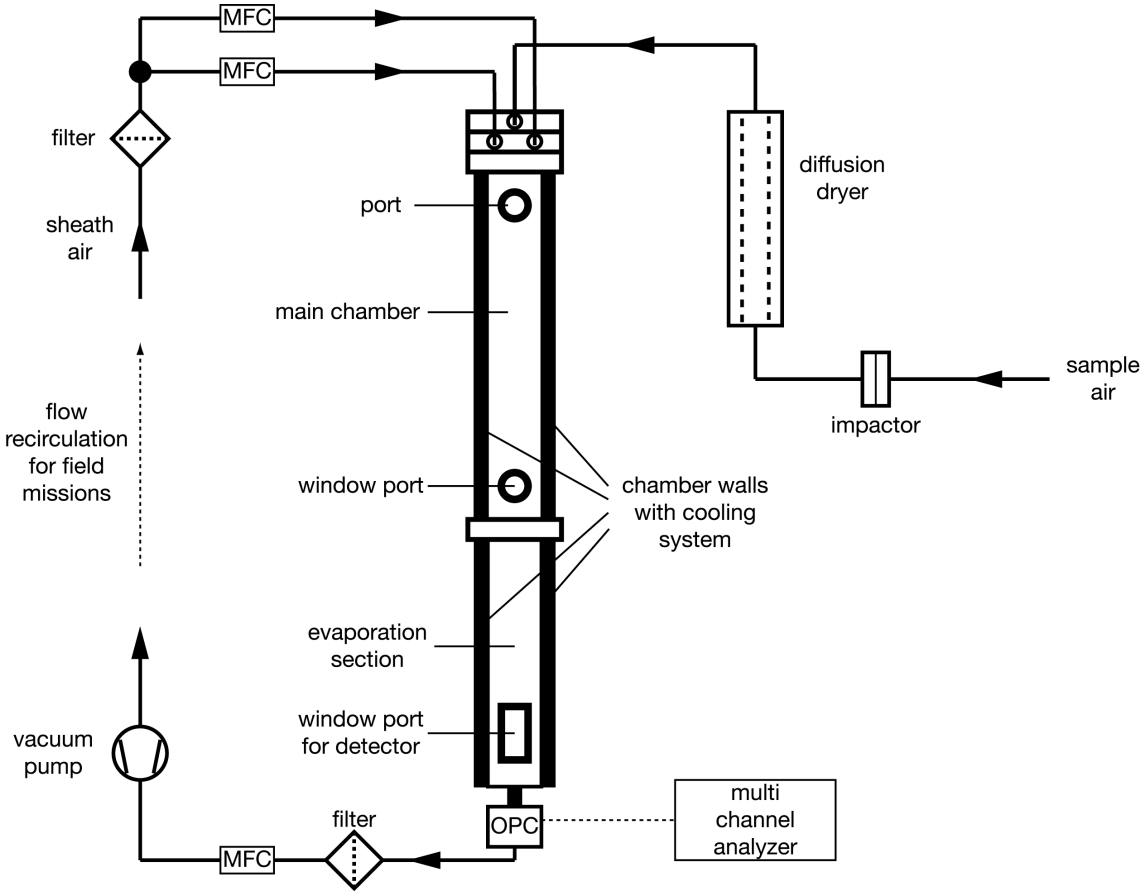
The Zurich Ice Nucleation Chamber (ZINC) is based on the principle of the Continuous Flow Diffusion Chamber by Dave Rogers and Paul DeMott (Colorado)

These chambers generally consist of two cooled, ice covered walls (Colorado: two cylinders, ZINC: two parallel plates).

Between these walls a laminar flow of air containing the sample aerosol is drawn.

The sample flow (typically 10% of the total flow) is layered in between two clean, particle free sheath flows.

Ice crystals are detected at the outlet of the chamber (OPC)




Stetzer, et al. 2008, The Zurich Ice Nucleation Chamber (ZINC) - A New Instrument to Investigate Atmospheric Ice Formation, Aerosol Science and Technology ; 42 (1) ; 64 - 74

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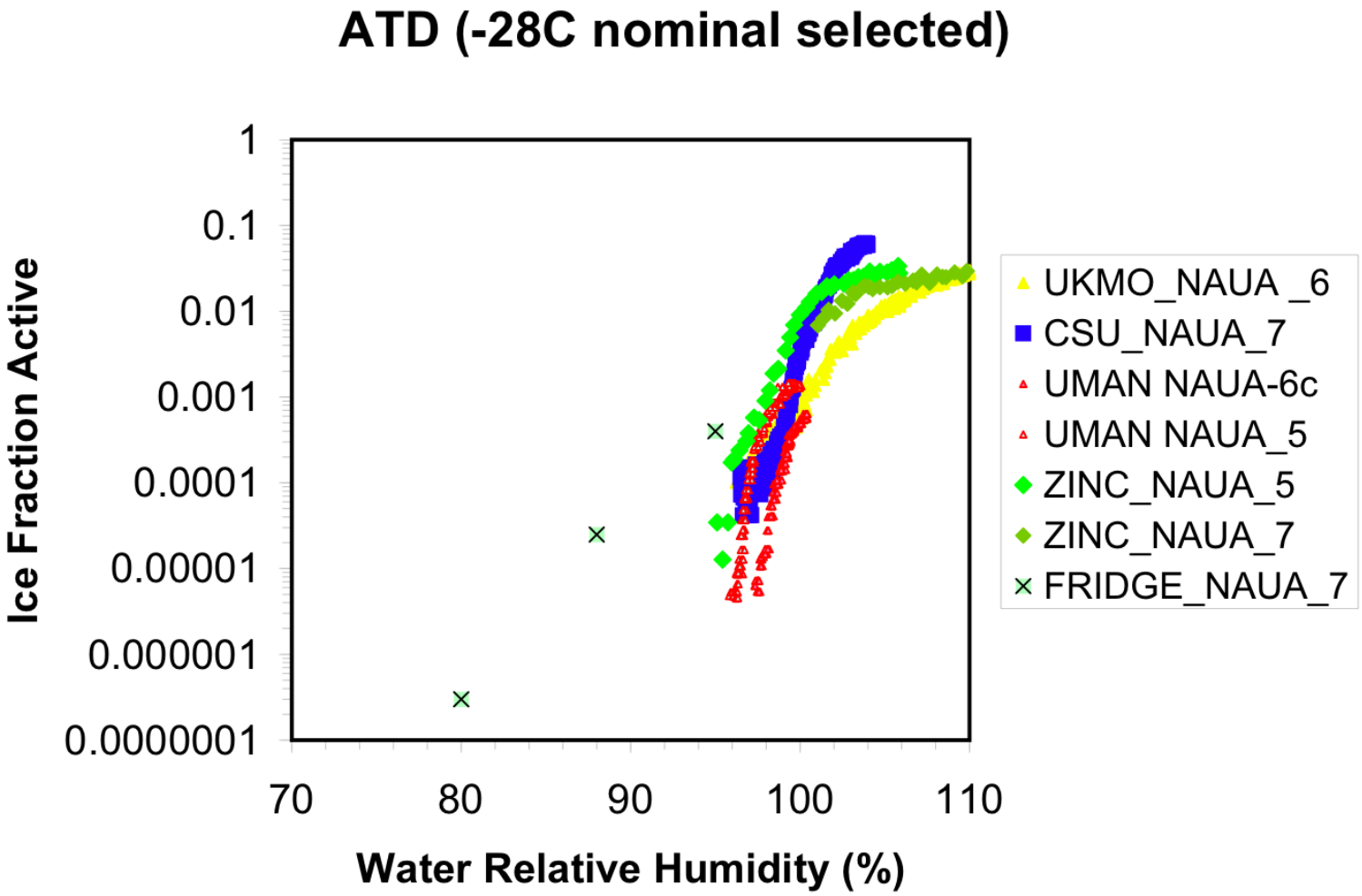
# ICIS 2007 Workshop

In September 2007, the ICIS Workshop was held in Karlsruhe at the AIDA chamber. The main objective was to compare as many currently available IN measurement instruments as possible using a variety of test aerosols. Below is a preliminary comparison plot for ATD:

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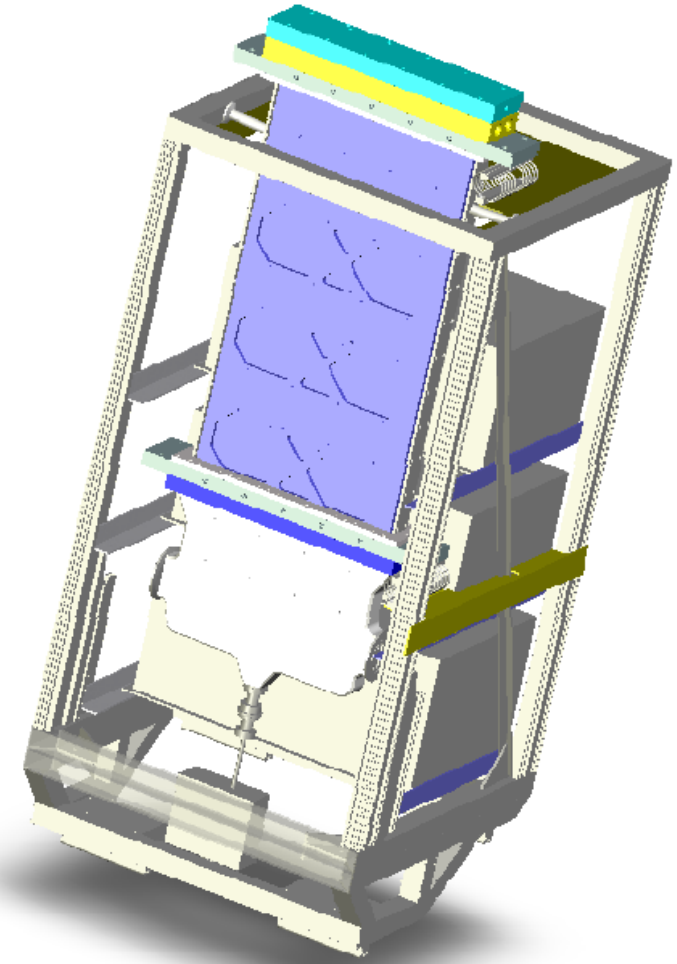
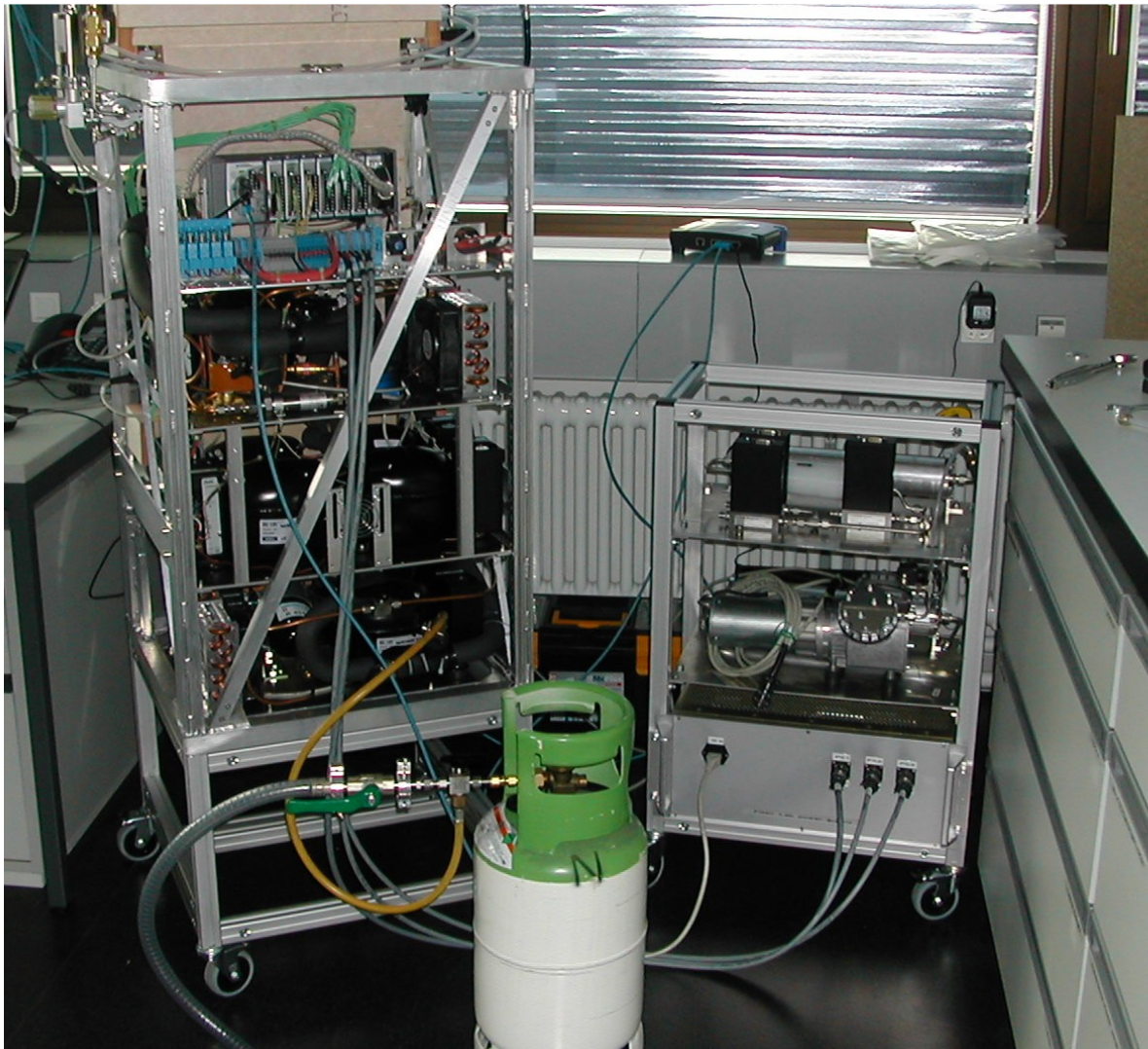
# PINC: Aircraft integration

After modifications to the cooling system and integration into an aircraft-certified rack, the field version on ZINC: PINC is now ready for flying!

Test campaign on a Learjet: this week in Hohn (northern Germany)!





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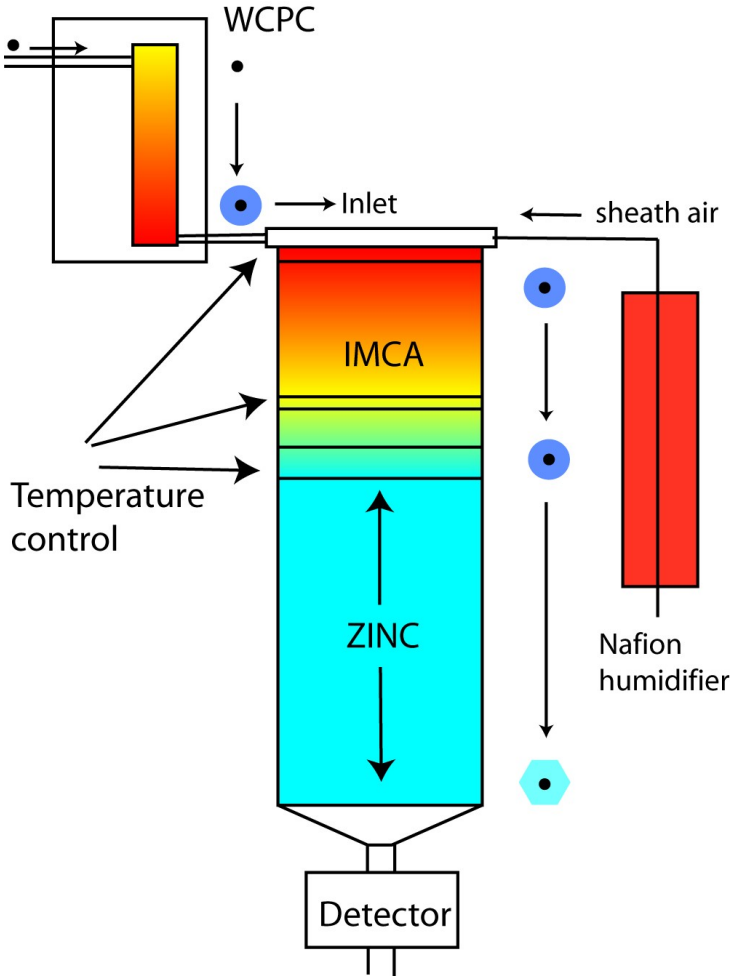
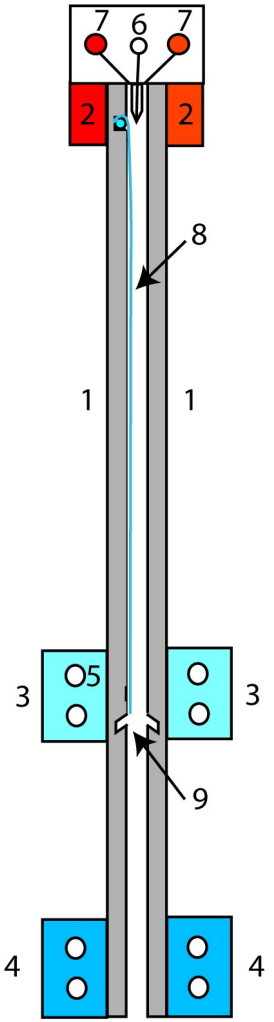
# Immersion Freezing studies

## Experiment on Immersion Freezing with the IMCA Chamber




1 Chamber walls
2 Heating elements
3 Intermediate coolers
4 Low temp coolers
5 Cooling liquid tubes
6 Aerosol inlet
7 Sheath air inlets
8 Humid filter paper
9 Water channels

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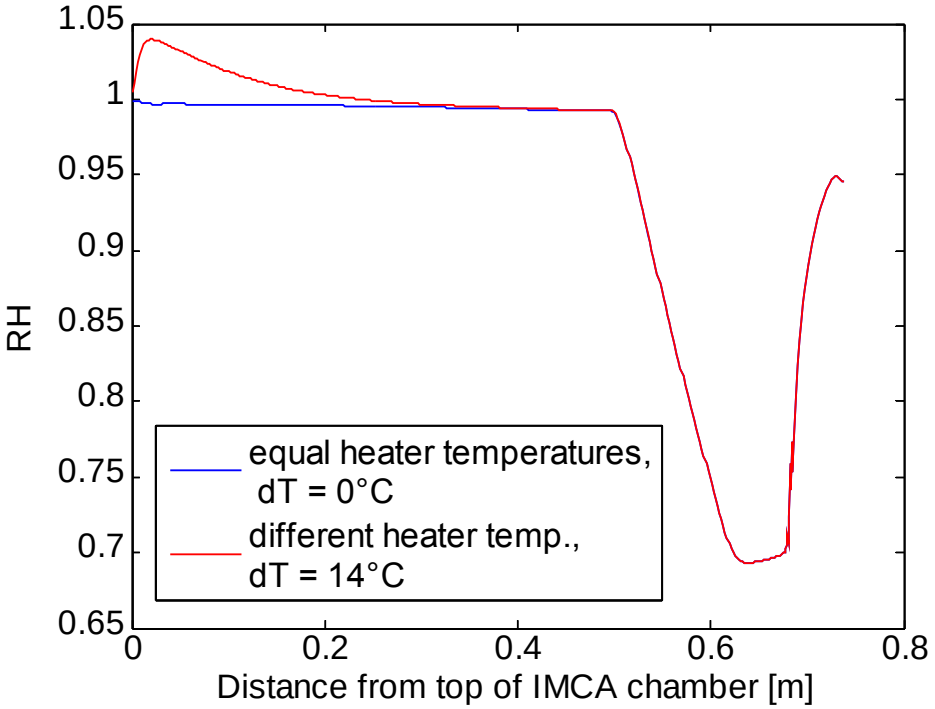
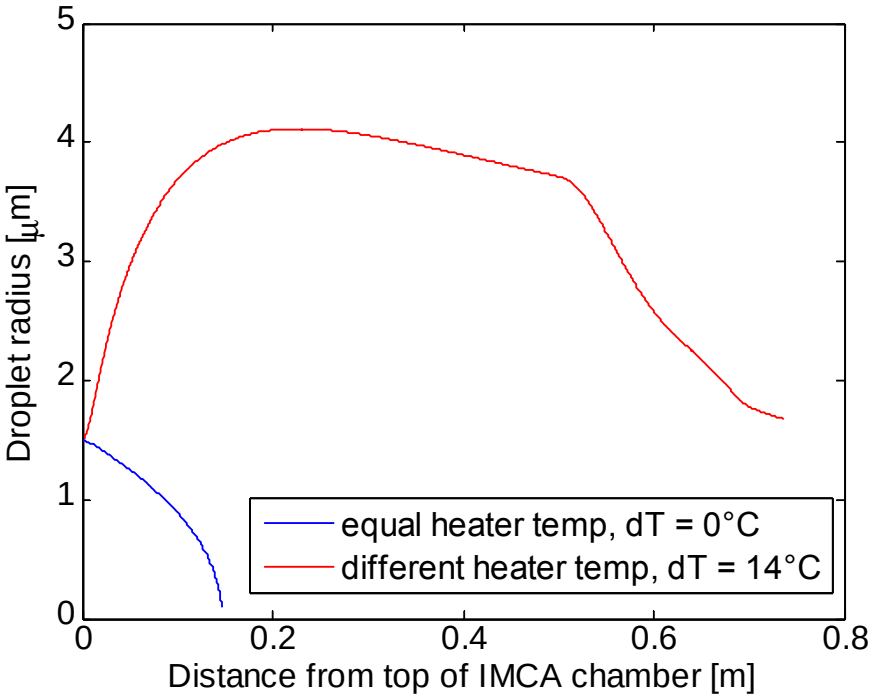
# Immersion Freezing studies

## Condensation and Evaporation of droplets in IMCA: Simulations




- Droplets of roughly 3 µm in diameter are extremely sensitive to evaporation
- Droplets evaporate in IMCA chamber without supersaturation
- Applying different temperatures to the walls at the top of IMCA → supersaturation
- With dT=14°C, droplets grow enough to "survive" dry conditions in lower part of IMCA

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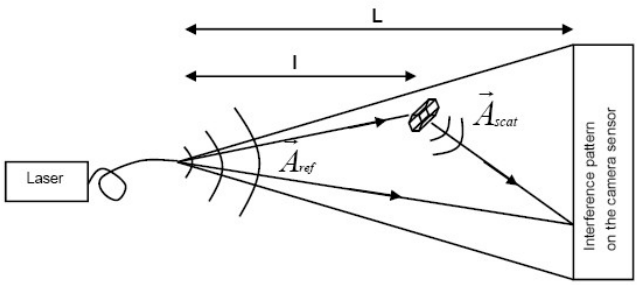
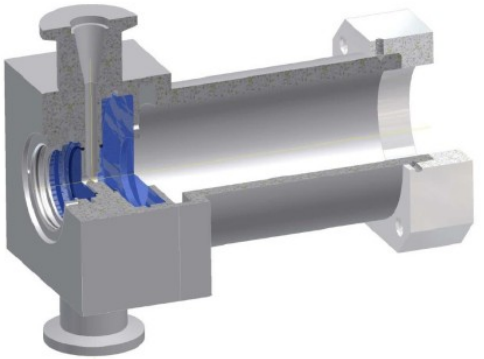
# Ice crystal imager: HOLIMO

- HOLographic Instruments for Microscopic Objects (HOLIMO)
- HOLIMO was operated during an AIDA ice nucleation campaign in fall 2007.
- A pulsed laser coupled into a single mode fiber is used as a point source.
- The spherical wave and the scattered light of ice crystals form an interference pattern on the detector (a digital camera).
- Objects are reconstructed from Holograms numerically.

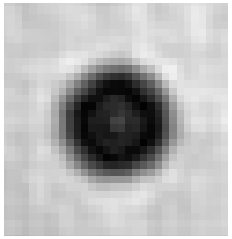
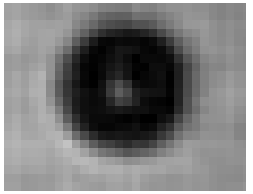
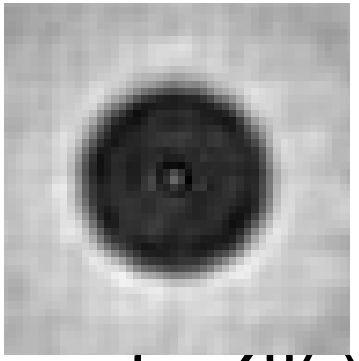
- Setup
  - L=132.5mm
  - λ=532nm
  - $t_{puls}$=1ns
  - 11<m<17
  - V=8mm$^3$



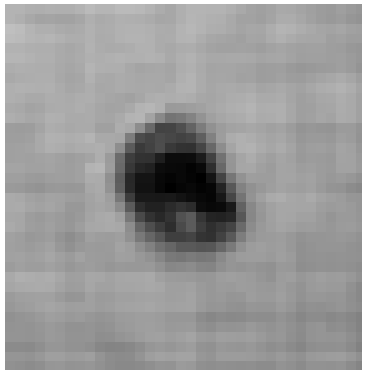
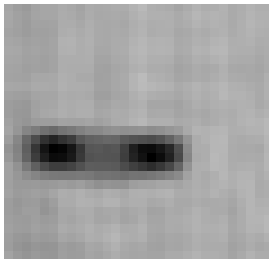
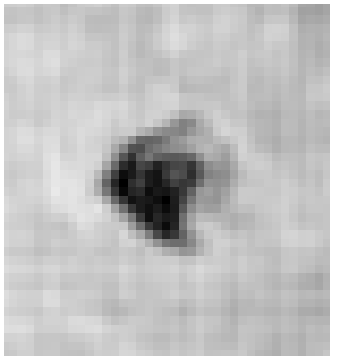
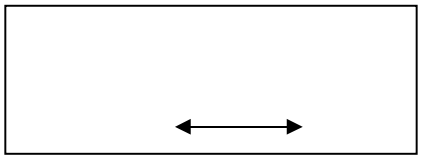



# Results (experiment 1: T= -18°C)

--droplets (ice subsaturated)

--thick plates (ice supersaturated up to 7%)

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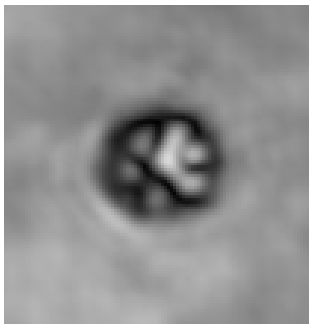
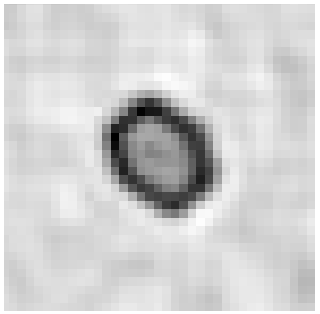
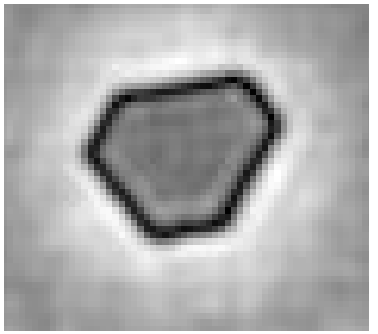

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# Hygroscopicity Tandem Differential Mobility Analyser (HTDMA) Setup

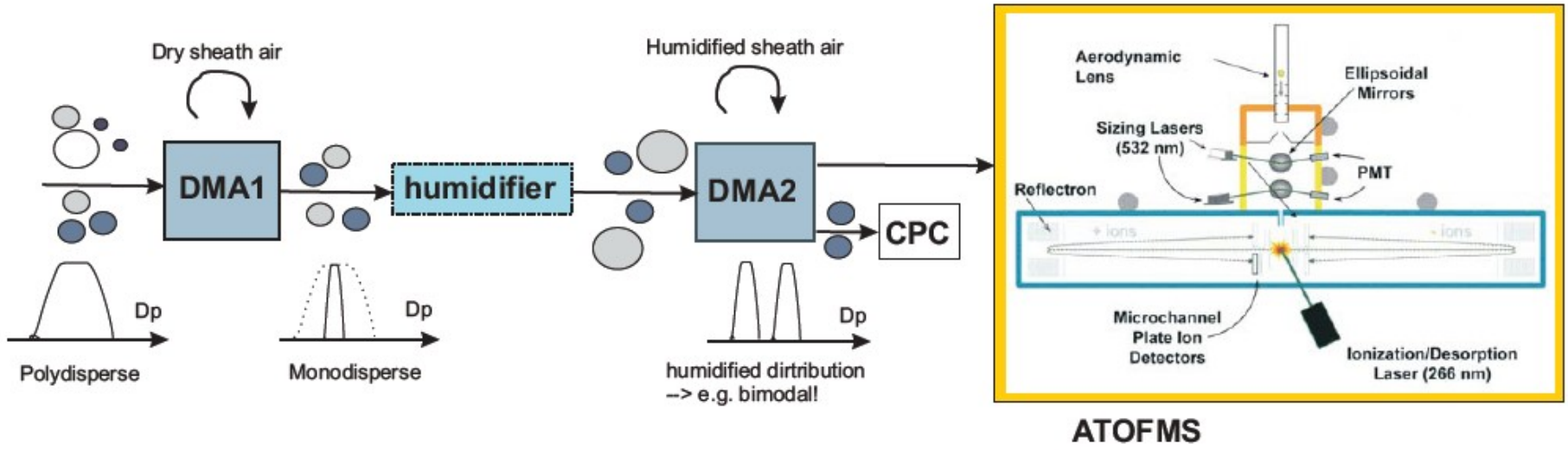


Figure: Setup

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# Measurements

Setup conditions: 82% RH, 260nm $d_0$ size.

- Proof of Concept
  - Sodium Nitrate coated PSL
- Data Collection:
  - Urban Zurich, less than 2 days, 3500 mass spectra
  - Remote high alpine station Jungfraujoch (JFJ), 9 days, 54 mass spectra
  - Abisko, Sweden, 200km north of the Arctic Circle, 2-3 datasets, ca. 250 mass spectra

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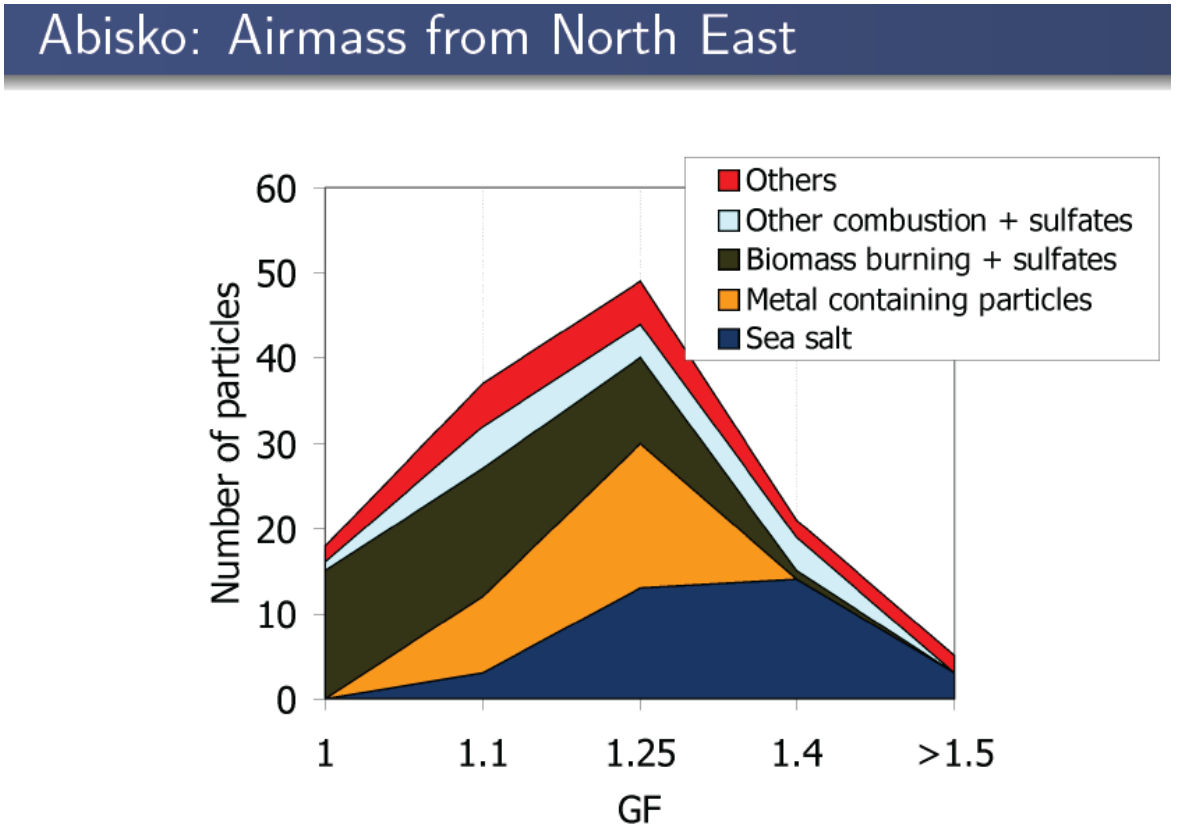
# Results Zurich (/JFJ):

Herich et al. 2008: In-situ determination of atmospheric aerosol composition as a function of hygroscopic growth, submitted to JGR

## Example results Abisko, Sweden:

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# Summary (1)

**IN studies:**

- ZINC successfully participated at the ICIS 2007 workshop. Comparison with other instruments (such as the CSU CFDC) is very good, some outliers still have to be analysed further.
- The „field“ and airborne version of ZINC: PINC is currently being tested on-board a Learjet in northern Germany.
- An extension to ZINC: IMCA for immersion freezing experiments has been modelled with FLUENT and IDL to optimize operating conditions. It is now being tested, first experiments will be performed soon.
- HOLIMO, the holographic ice crystal imager took pictures of ice crystals grown in the AIDA chamber in fall 2007. First results are shown, a publication is being worked on.

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# Summary (2)

**CCN and aerosol MS:**

- A hygroscopicity tandem DMA (HTDMA) has been succesfully coupled to an ATOFMS to retrieve chemical composition as a function of the growth factor. Field campaign data from Zürich, the Jungfraujoch and Abisco (Sweden) will be published soon.

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