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

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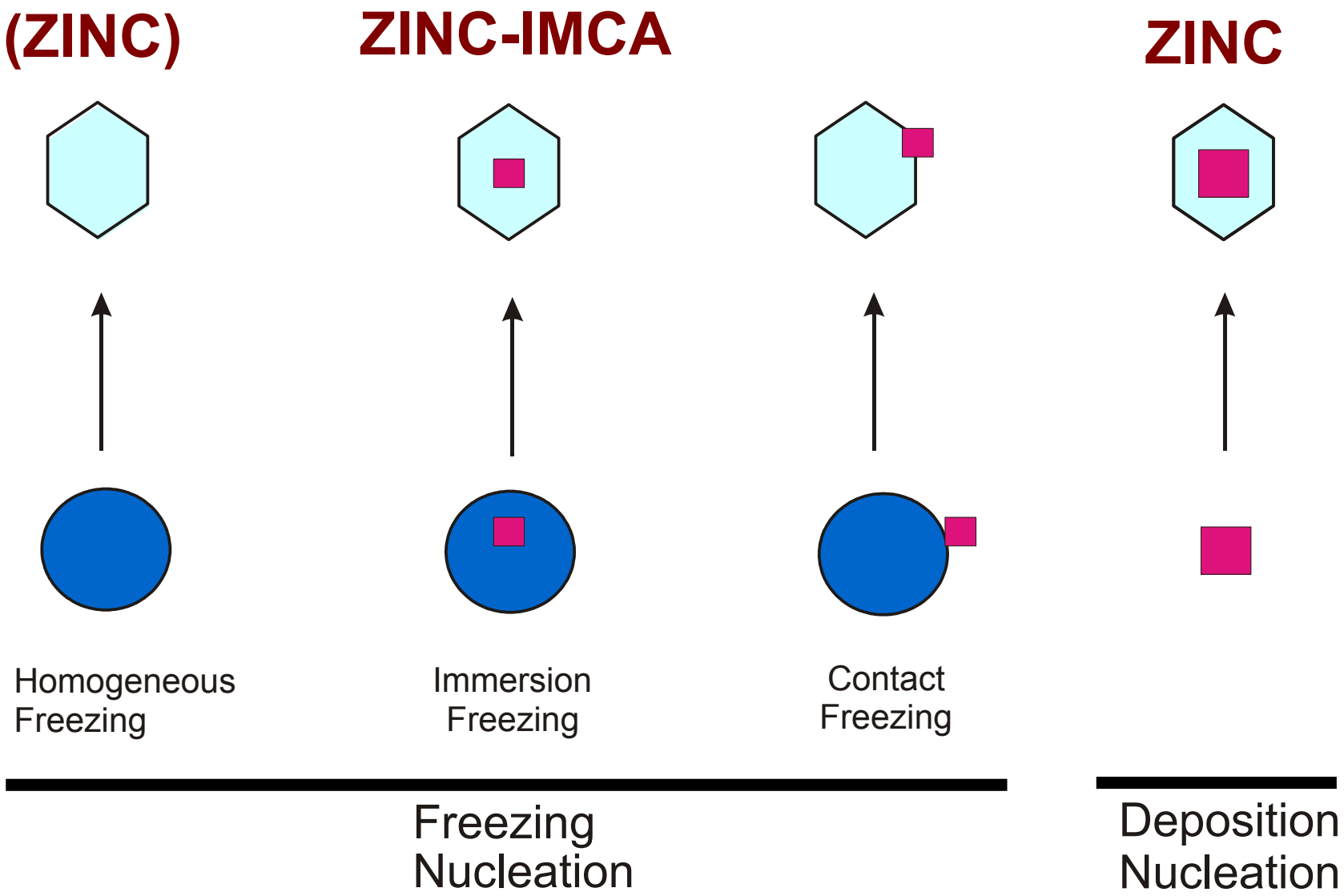
Overview:

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

- Ice Nucleation studies with ZINC
- Immersion freezing studies (ZINC-IMCA)
- Campaigns with PINC (FROST-II)
- Ice Particle Imaging at AIDA with our Holographic Microscope HOLIMO
- Summary

IN – mixed phase and cold clouds



Modes of Ice Nucleation (Vali, 1985)

Design concept of ZINC/PINC

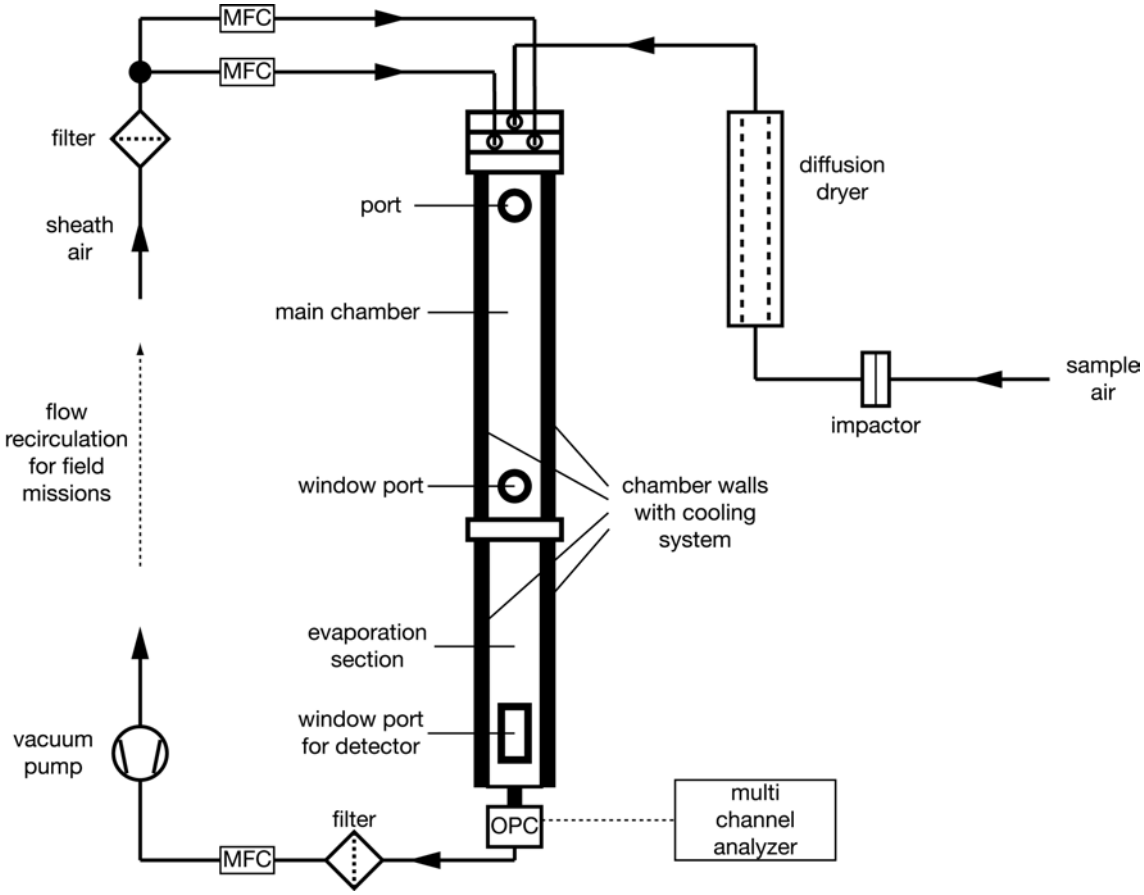
The Zurich Ice Nucleation Chamber (ZINC) is based on the principle of the Continuous Flow Diffusion Chamber by Dave Rogers and Paul DeMott (Colorado)

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

ZINC: size dependent IN of mineral dust

Size dependent ice nucleation studied with different mineral dusts (Kaolinite, Montmorillonite, Illite, and ATD (100, 200, 400, 800 nm). Results are under discussion in ACPD!

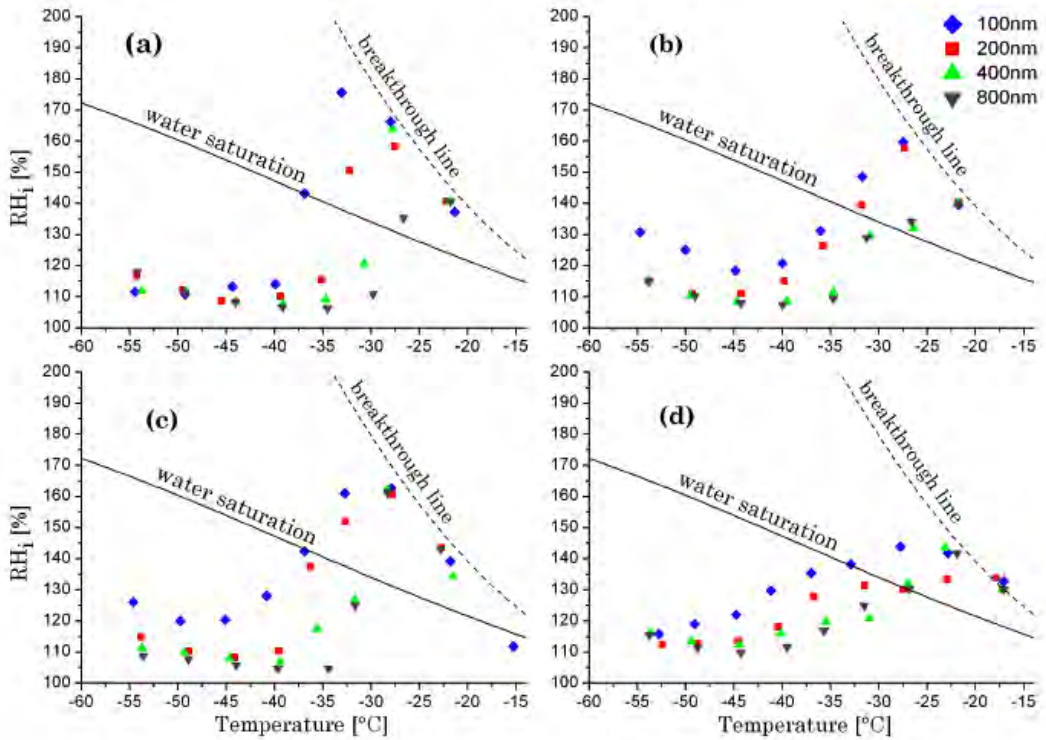


Fig. 5. RH$_i$ required for 1% activated fraction as a function of temperature of **(a)** montmorillonite, **(b)** kaolinite, **(c)** illite, **(d)** ATD for different particle sizes. The water saturation line is shown as a solid, black line. The breakthrough line marks the region where water drops condensed in the nucleation section, grow large enough to pass the evaporation section and thus are also detected by the OPC.

Influence of particle size on the ice nucleating ability of mineral dusts
A. Welti, F. Lüönd, O. Stetzer, and U. Lohmann
Atmos. Chem. Phys. Discuss., 9, 6929–6955, 2009

ZINC: size dependent IN of mineral dust

Sigmosoidal functions have been fit to the activation spectra:

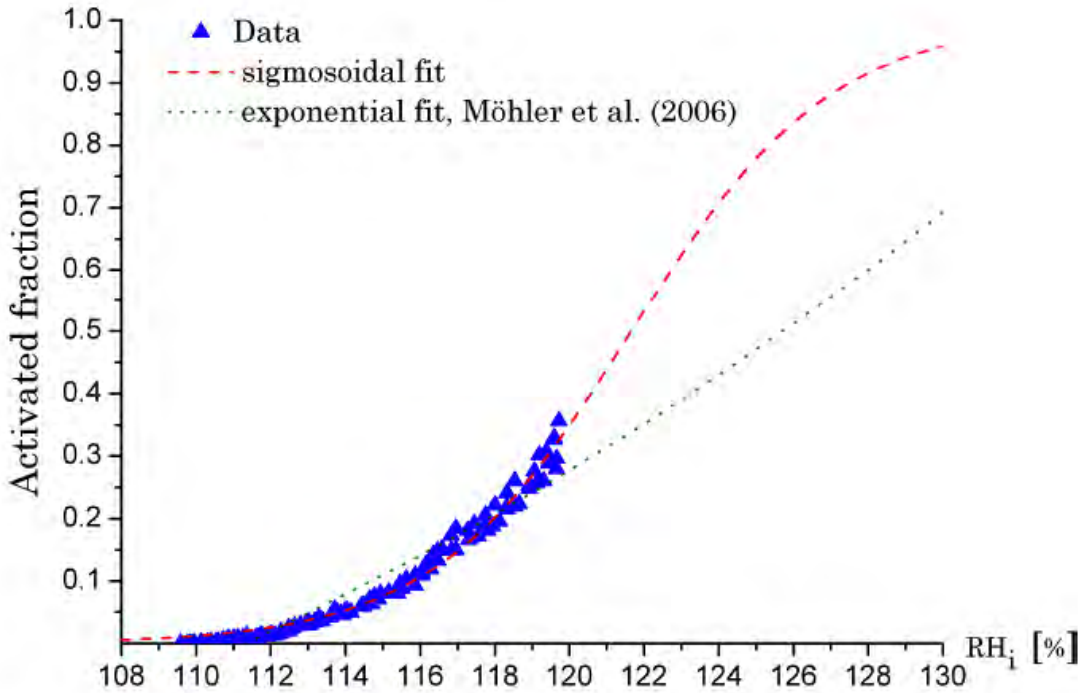
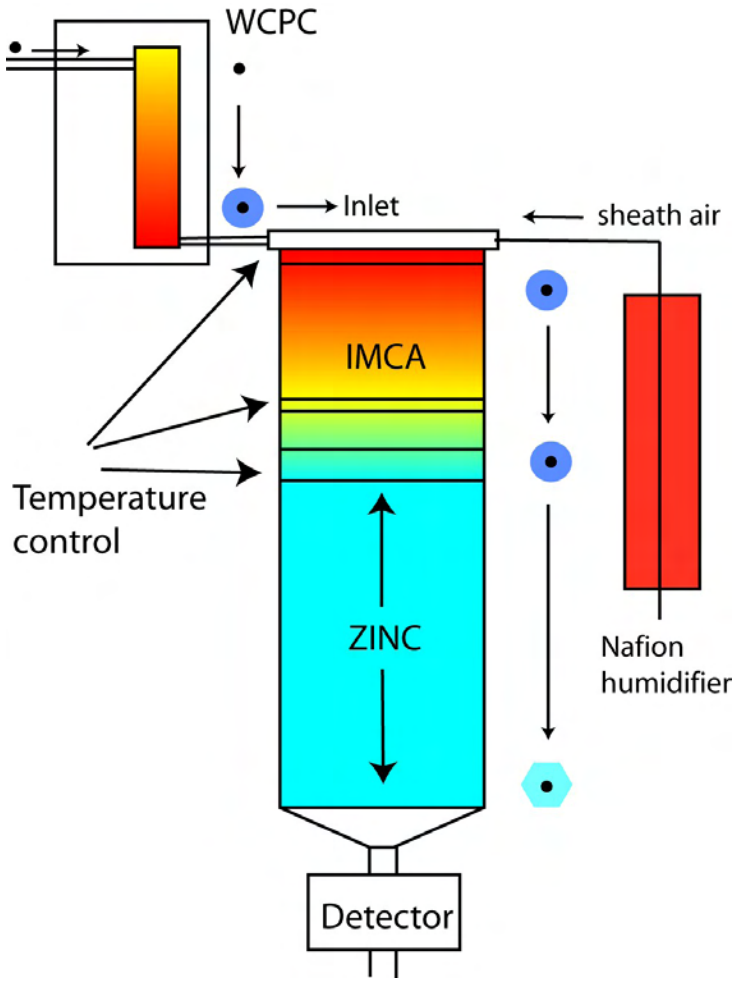
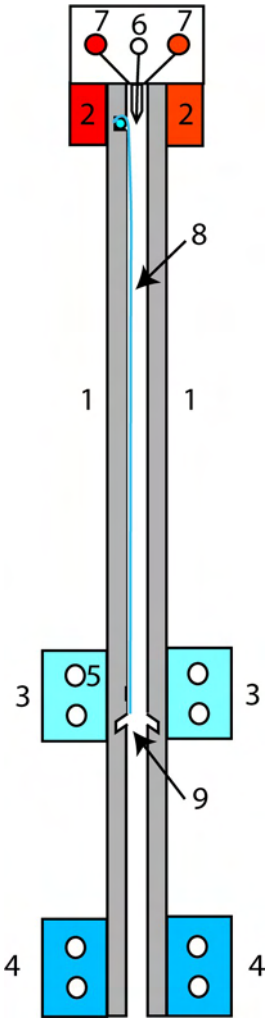


Fig. 7. Measured activation spectra at −55°C for 400 nm illite particles are shown as blue triangles. The least square fit of a sigmosoidal shaped curve according to Eq. (2) is depicted as dashed line. The least square fit of an exponential parameterisation according to Möhler et al. (2006) is shown as dotted line.

ZINC-IMCA: immersion freezing studies with mineral dust





1 Chamber walls

2 Heating elements

3 Intermediate coolers

4 Low temp coolers

5 Cooling liquid tubes

6 Aerosol inlet

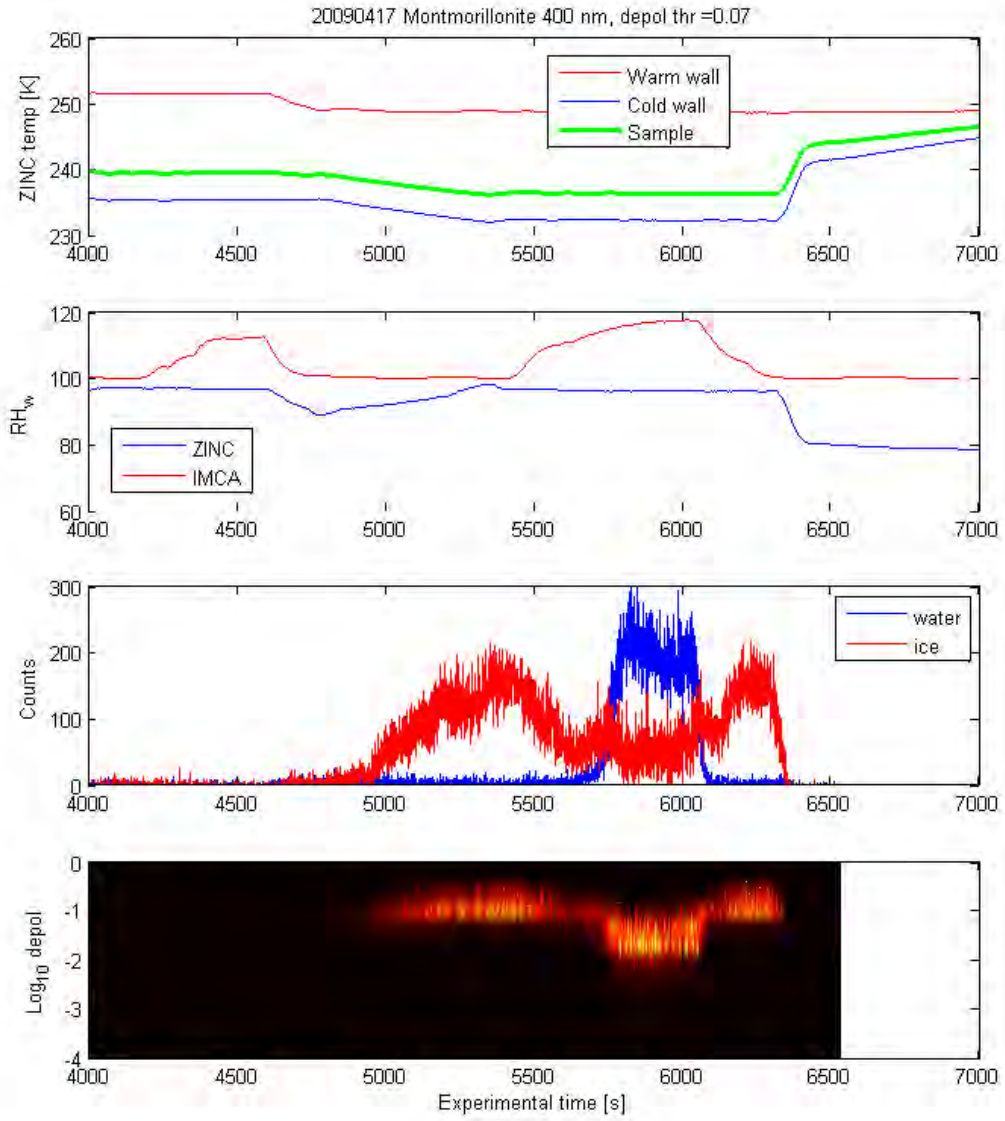
7 Sheath air inlets

8 Humid filter paper

9 Water channels

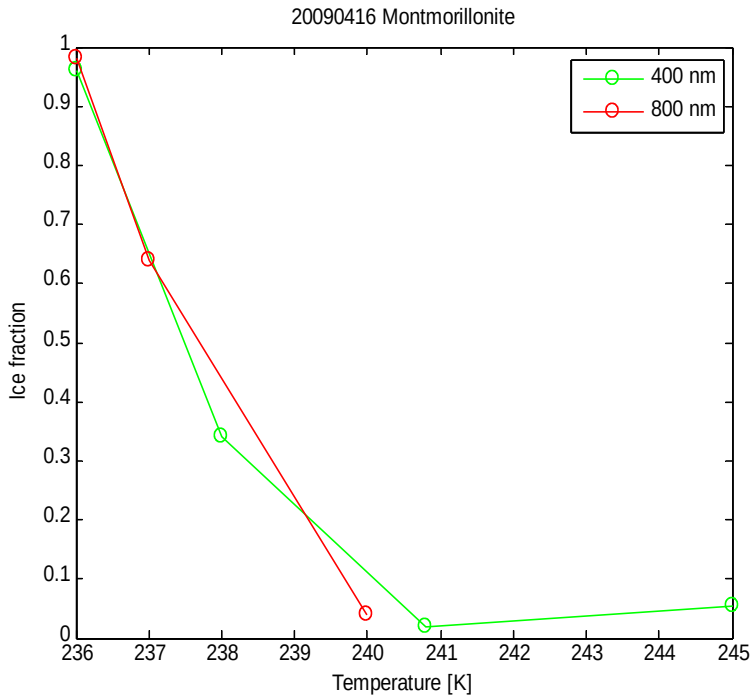
ZINC-IMCA: immersion freezing studies with mineral dust

First freezing results with IMCA and IODE with Montmorillonite:



Transition between deposition and immersion freezing observed

Different depol. ratios for both mechanisms – further analysis needed to exclude detection artifacts

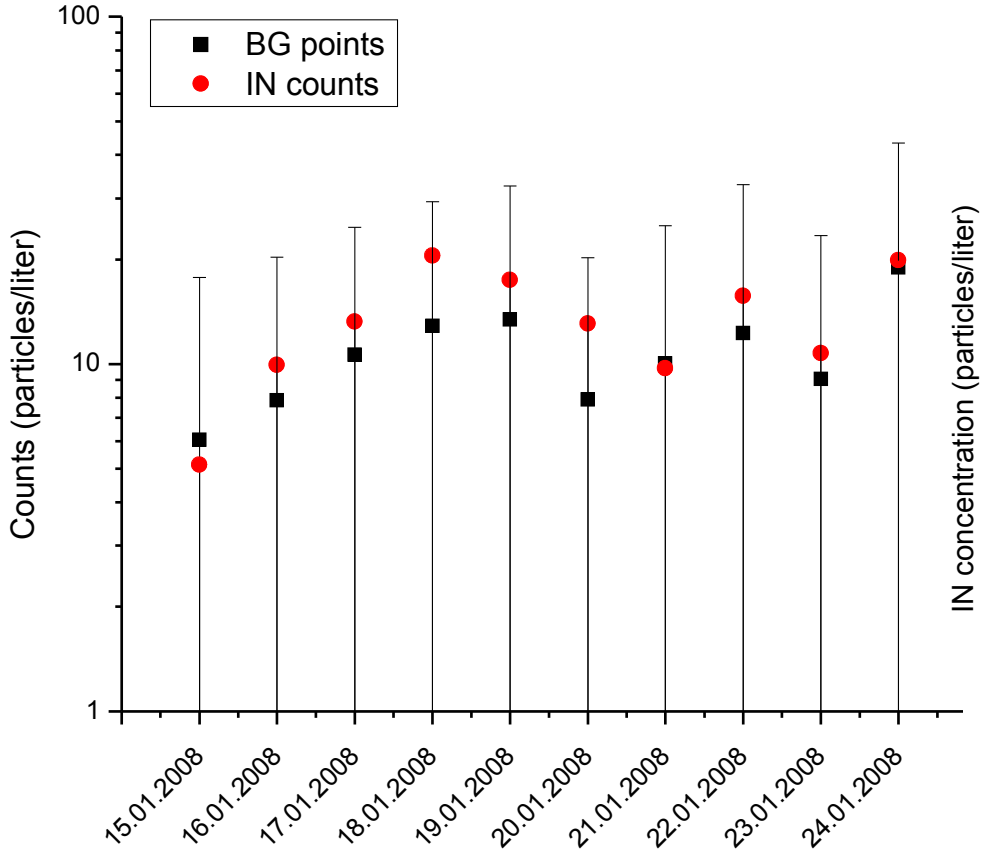


PINC: Improvements & FROST-II

After first test campaigns in 2008 several technical improvements have been implemented and their effectiveness could be demonstrated during a campaign on the Jungfraujoch:

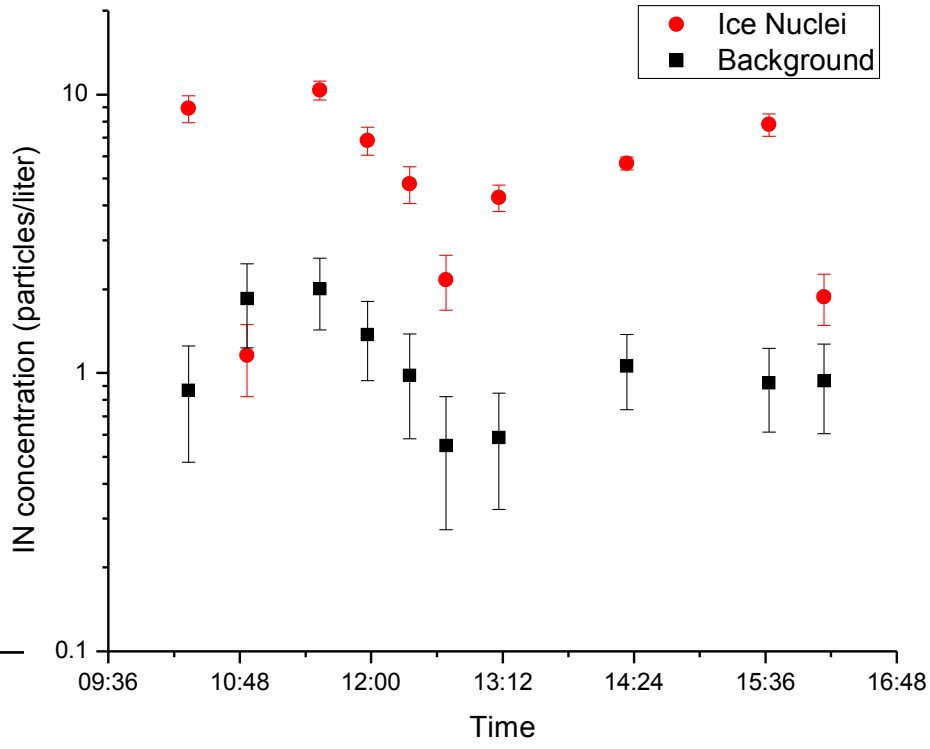
Old Version: Data from Jan 2008

Stdev. of counts



New Version: Data from 1. March 2009

Poisson statistics



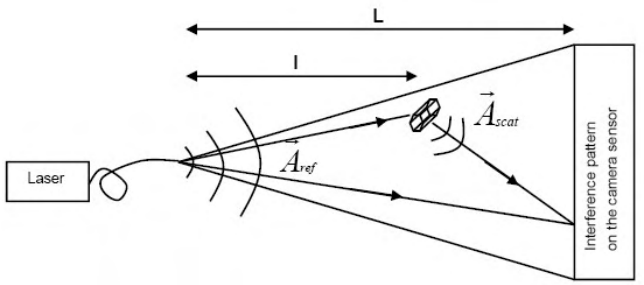
PINC: Improvements & FROST-II

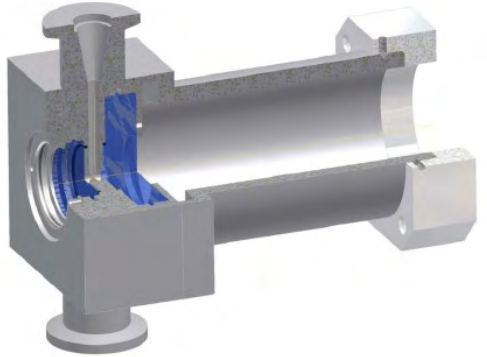
PINC has recently participated at the FROST-II campaign in Leipzig (data has yet to be analyzed)

Ice crystal imager: HOLIMO

- HOLographic Instruments for Microscopic Objects (HOLIMO)
- HOLIMO was operated during AIDA ice nucleation campaigns in fall 2007 and 2008.
- 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



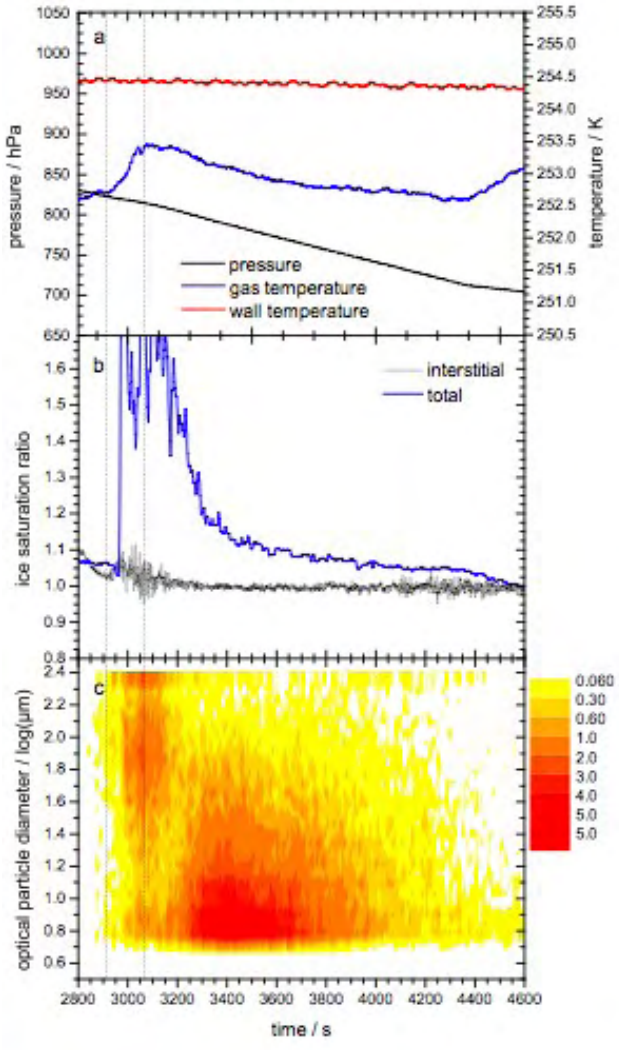


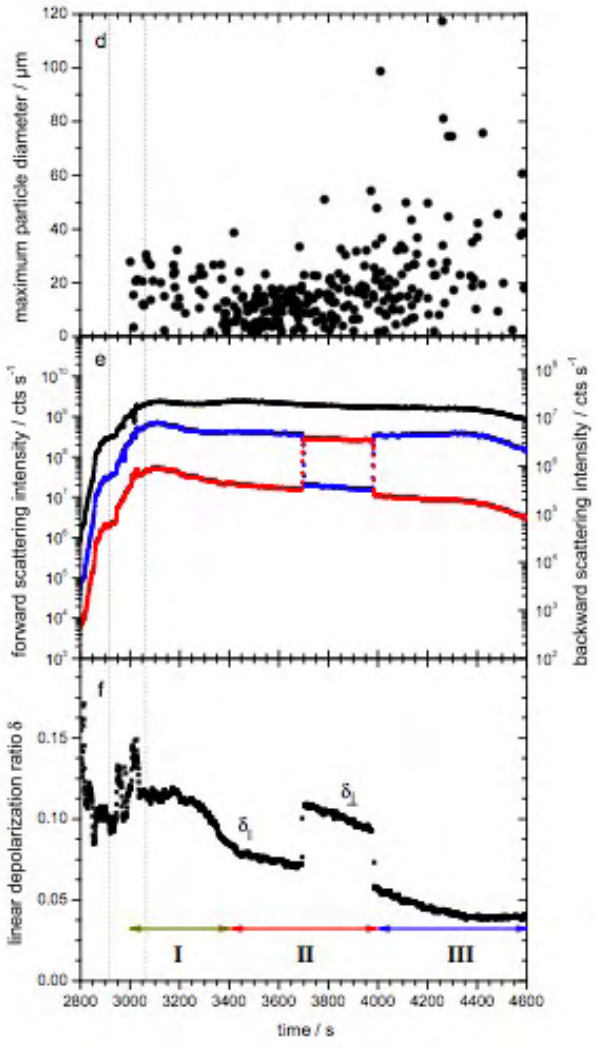
Ice crystal imager: HOLIMO

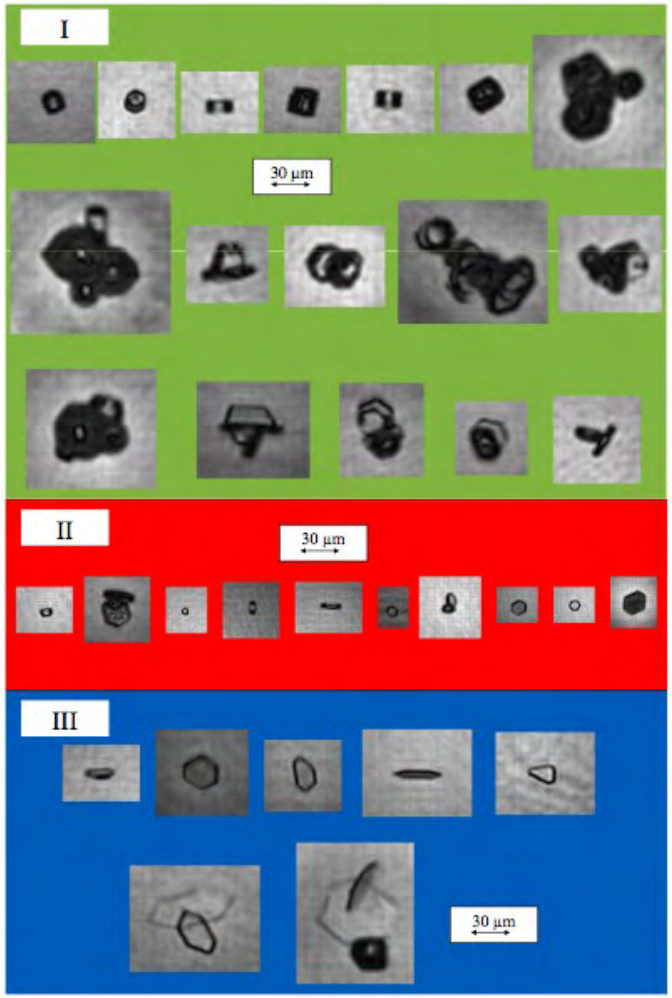
Results from AIDA campaign: Ice crystal habits with large aspect ratios (plates) show unexpectedly small depolarizations

Submitted to **Applied Optics**: Ice crystal habits from cloud chamber studies obtained by in-line holographic microscopy related to depolarization measurements

Peter Amsler, Olaf Stezer, Ulrike Lohmann, Martin Schnaiter, Stefan Benz, Ottmar Moehler, Evelyn Hesse







Summary

- ZINC measurements with different mineral dusts show clear size dependent ice nucleation (larger particles activate better). Publication currently under discussion in ACPD.
- The „field“ and airborne version of ZINC: PINC has been tested and improved in 2008. The new version was successfully deployed during a Jungfraujoch campaign and during FROST-II.
- An extension to ZINC: IMCA for immersion freezing experiments has been finished – experiments are on the way. First results with the IODE depolarization detector are promising.
- HOLIMO, the holographic ice crystal imager took pictures of ice crystals grown in the AIDA chamber in fall 2007 and 2008. A correlation between small depolarization ratios and plate-like crystals with large aspect ratios has been found. Publication is under review in Applied Optics.