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May, 10th/11th, VI-ACI annual meeting, Zürich

TDL water measurements at AIDA – recent developments and applications

Outline

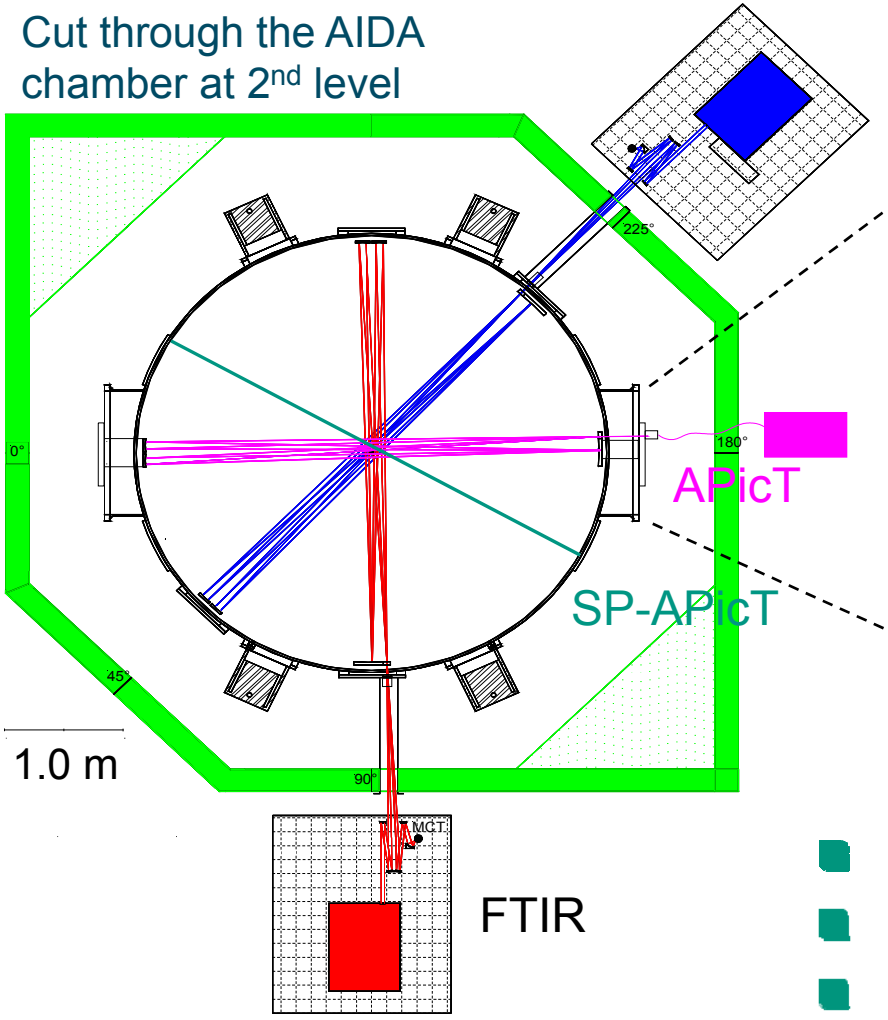
- AIDA-TDL overview
- Recent instrumental progression
- Application to cloud micro physics
- Summary & Outlook

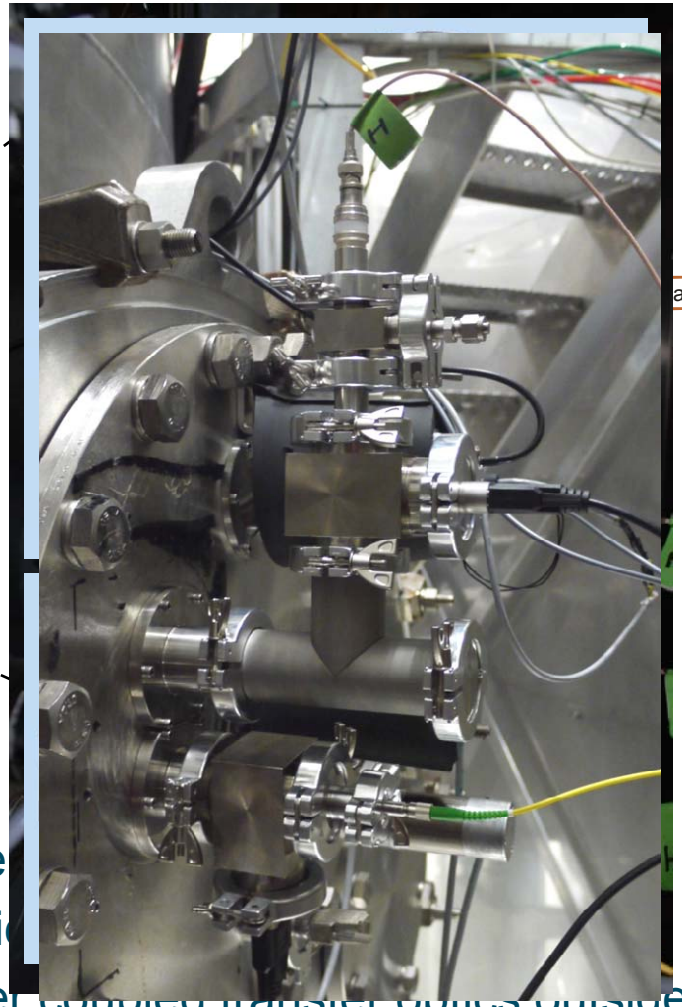
AIDA-TDL overview

- **In situ measurement of water vapor:**
  - White cell with TDL absorption spectrometer (APicT)
  - New: Single path TDL (SP-APicT) for high concentrations
- **Measurement of total water**
  - Extractive TDL absorption spectrometer (APeT)
  - Sampling via heated (30 °C) stainless steel tubes
- **TDLAS based measurement of condensed water**
  - Difference between total water and in situ water vapor

Progress of the in situ TDL (APicT)

Cut through the AIDA chamber at 2nd level





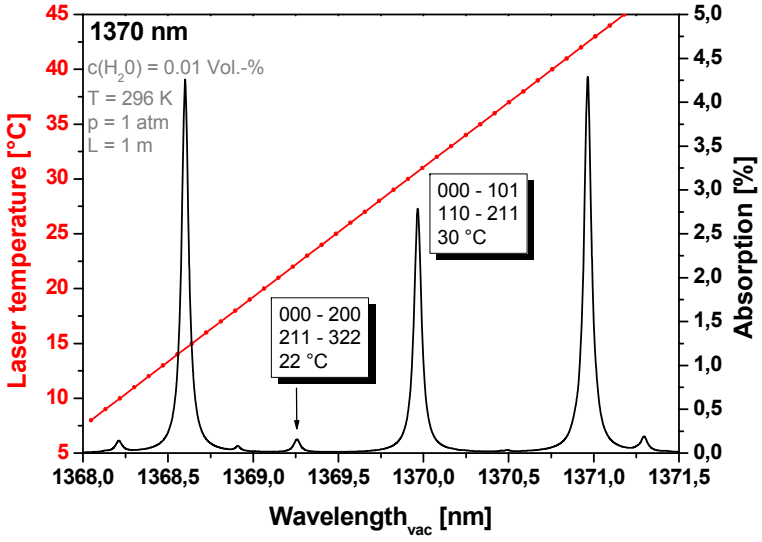
- Ope
- Opti
- Fiber coupled transfer optics outside the AIDA chamber ⇒ parasitic absorption

TDLAS increased dynamic range

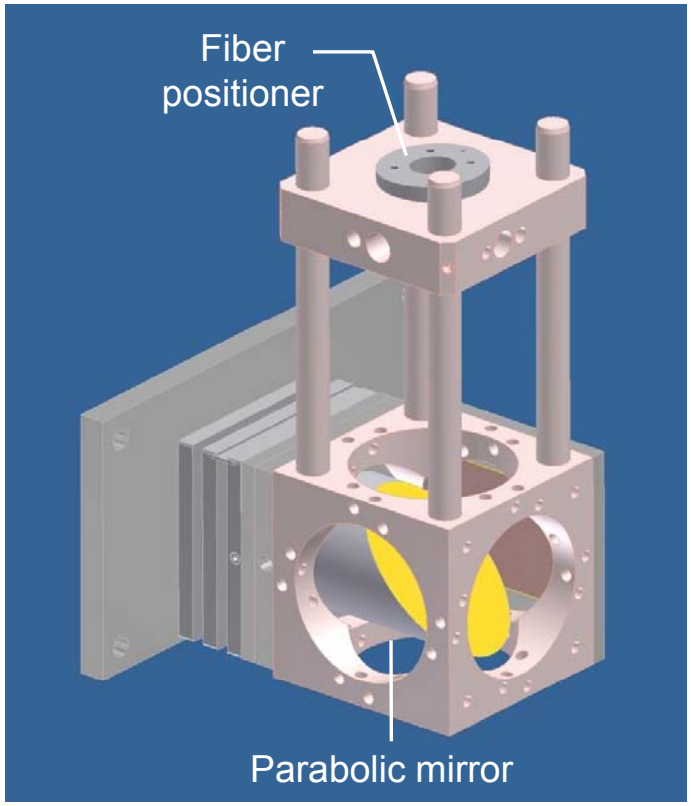
Goal: from 2000 ppm to 10000 ppm

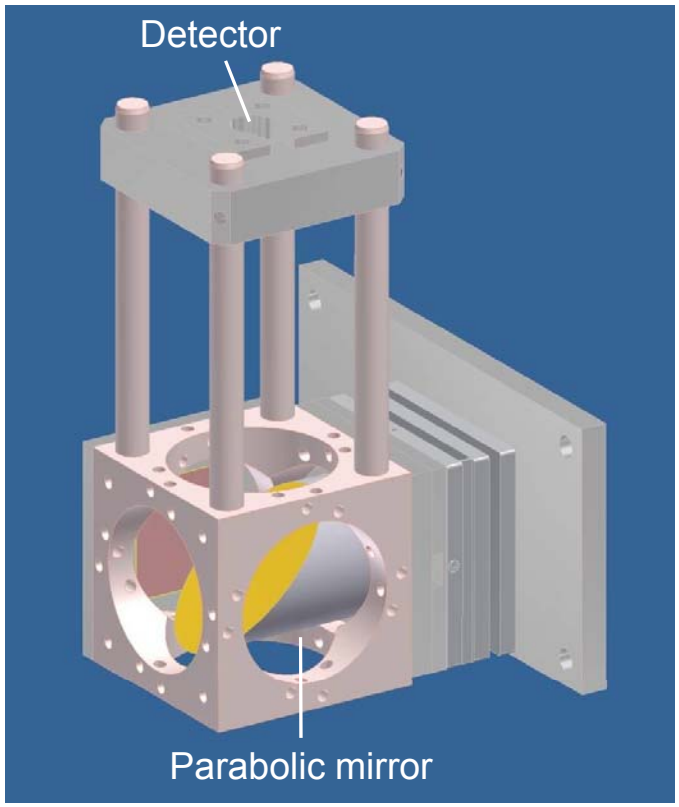
Two possibilities for high water concentrations

- Switch to weaker absorption line
  ⇒ strong interference with adjacent lines
  ⇒ systematic uncertainties, complicated fitting
- Decrease of optical path length ⇒ SP-APicT
  Additional advantage: low scattering losses ⇒ denser clouds



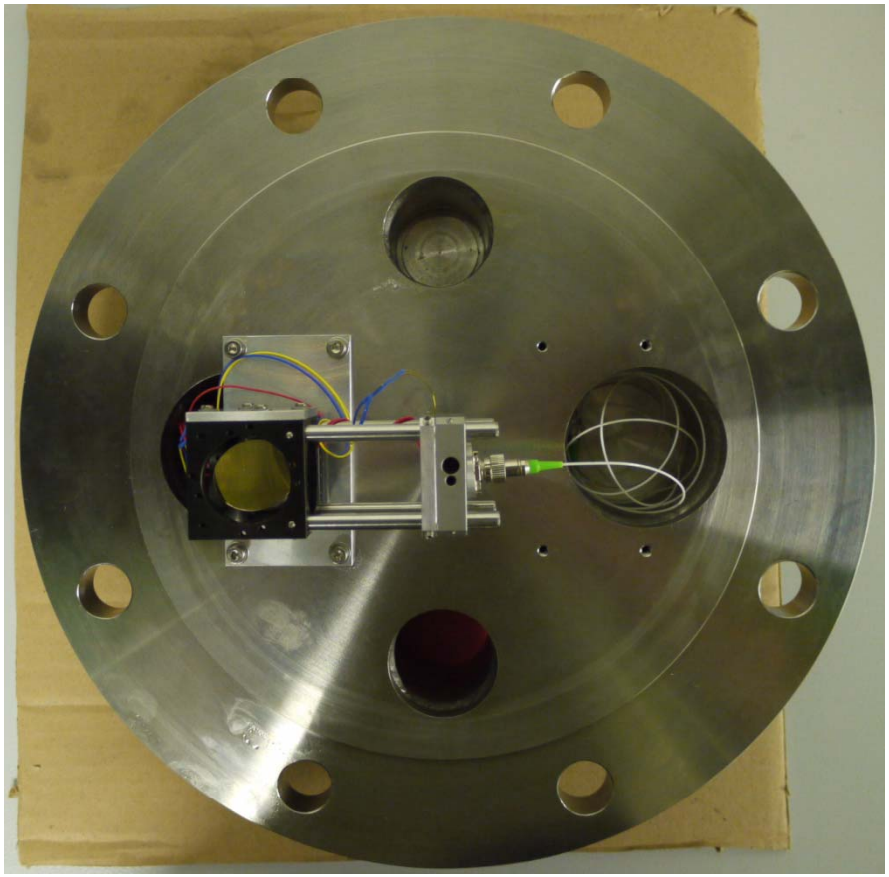
Single-path APicT



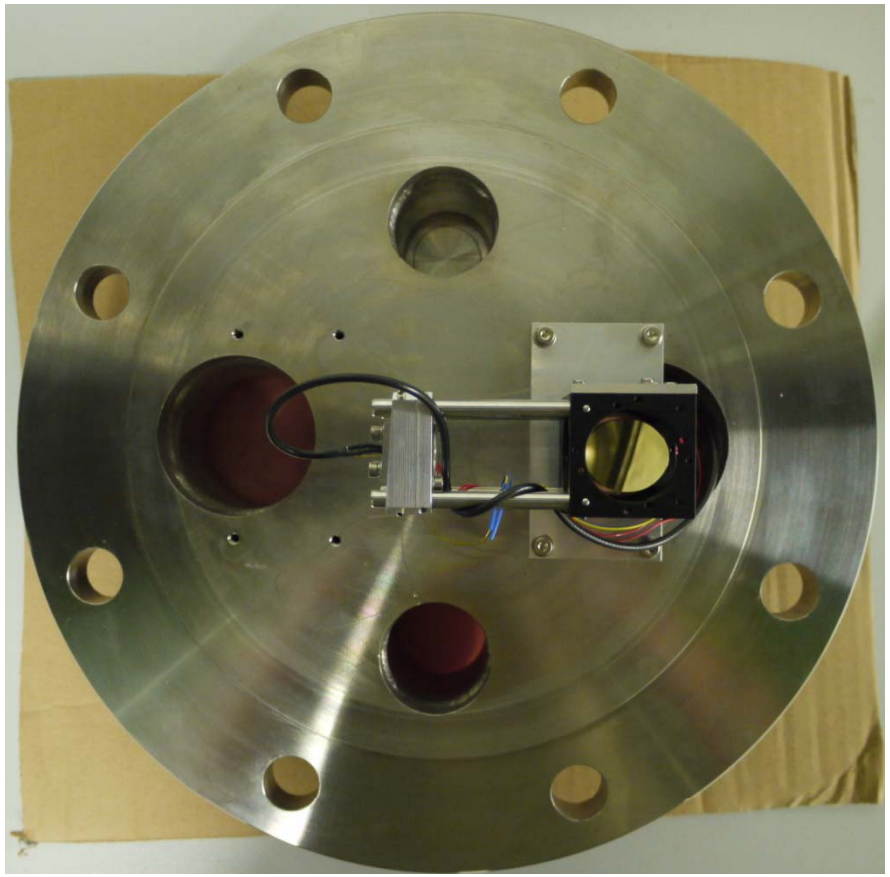


- Optical path length: 4.11 m
- Fiber-coupled optics inside AIDA chamber
- Minimized parasitic absorption

Single-path APicT – inside view

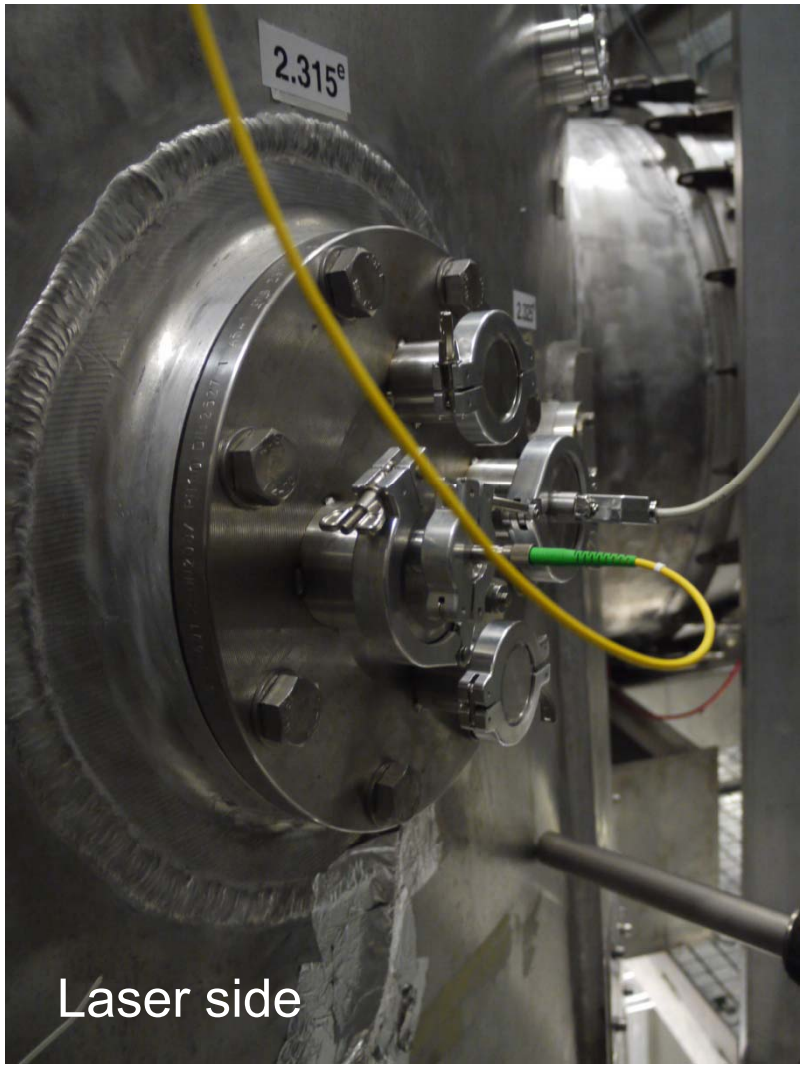


Laser side

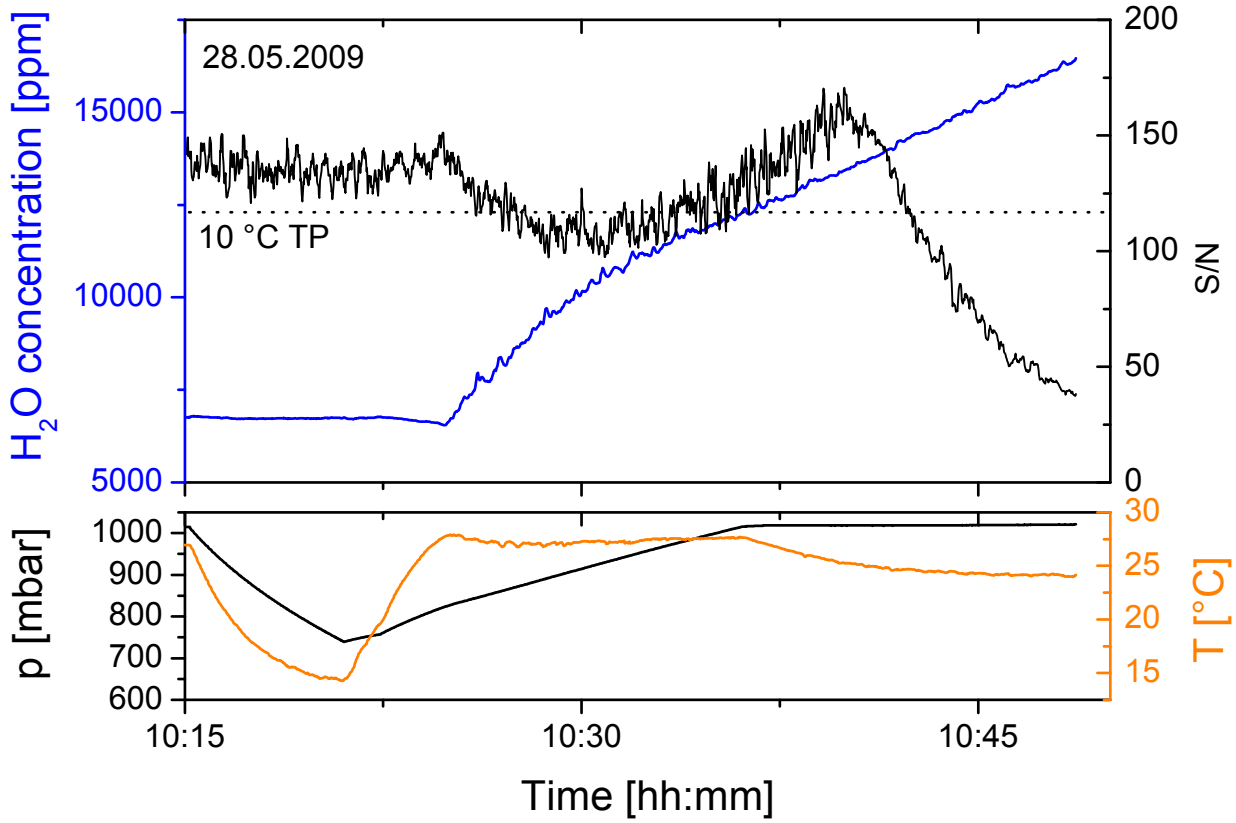


Detector side

Single-path APicT – outside view

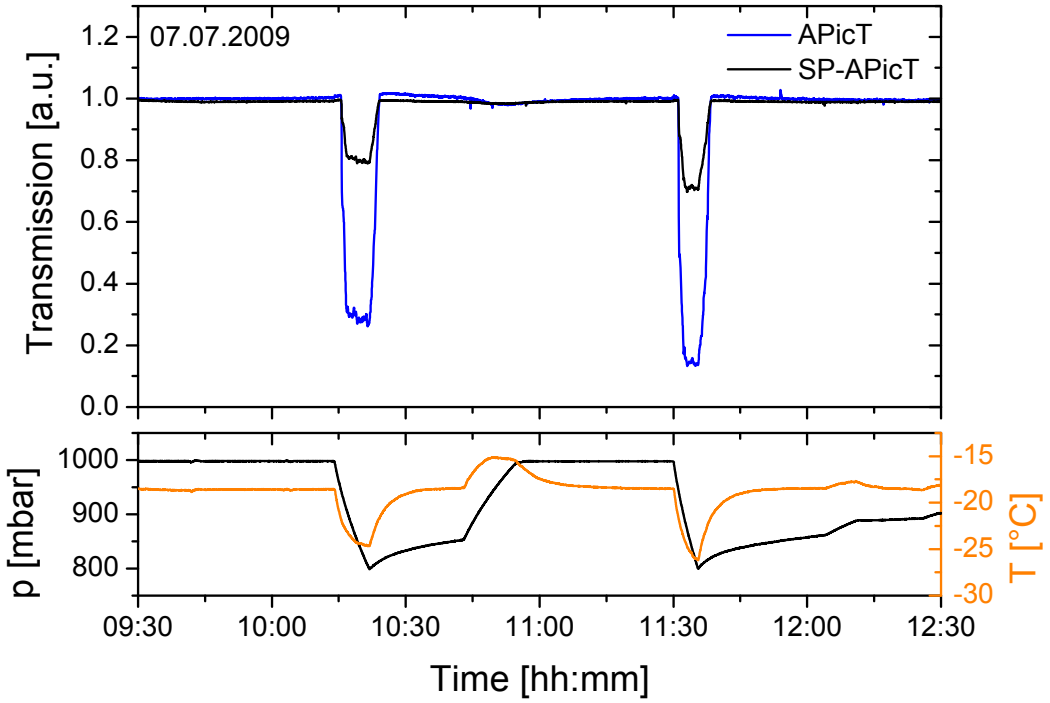


SP-APicT at high concentrations



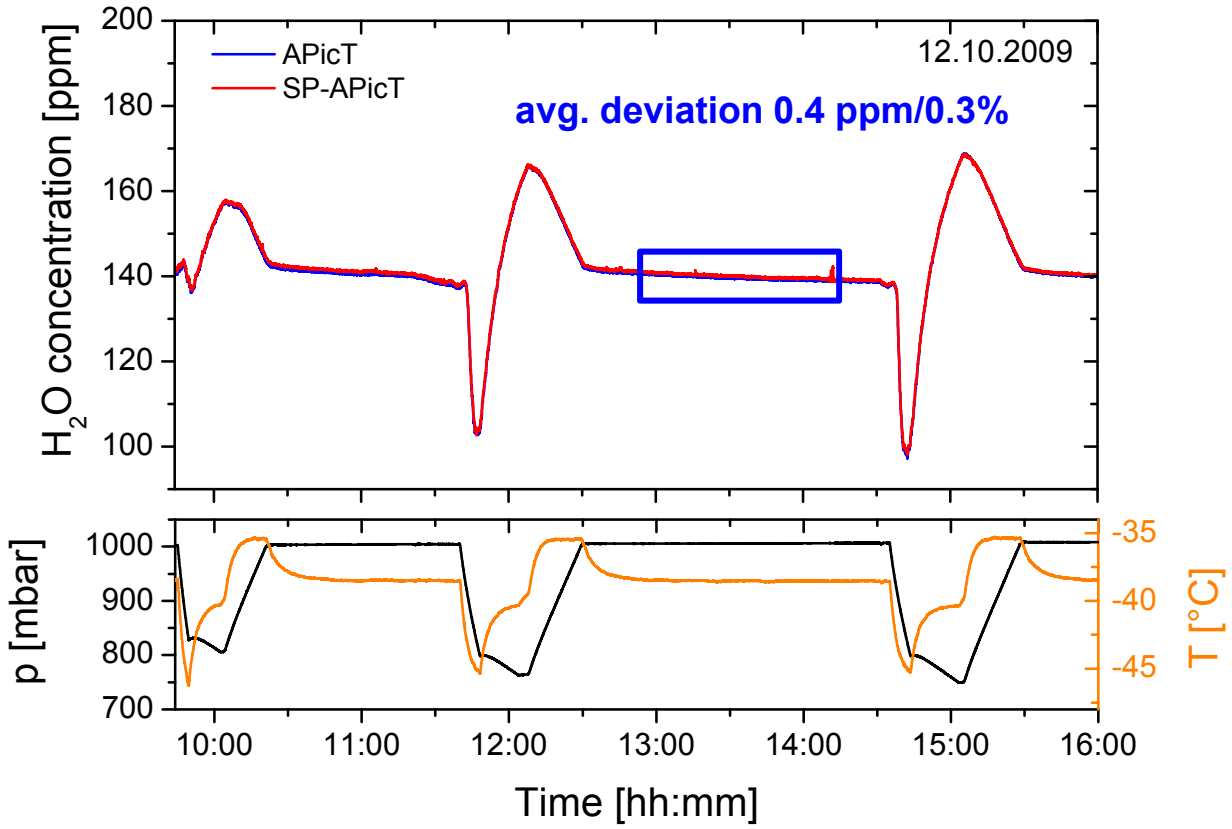
- Upper measurement limit above 12 000 ppm (10 °C DP)

Signal robustness vs. scattering losses



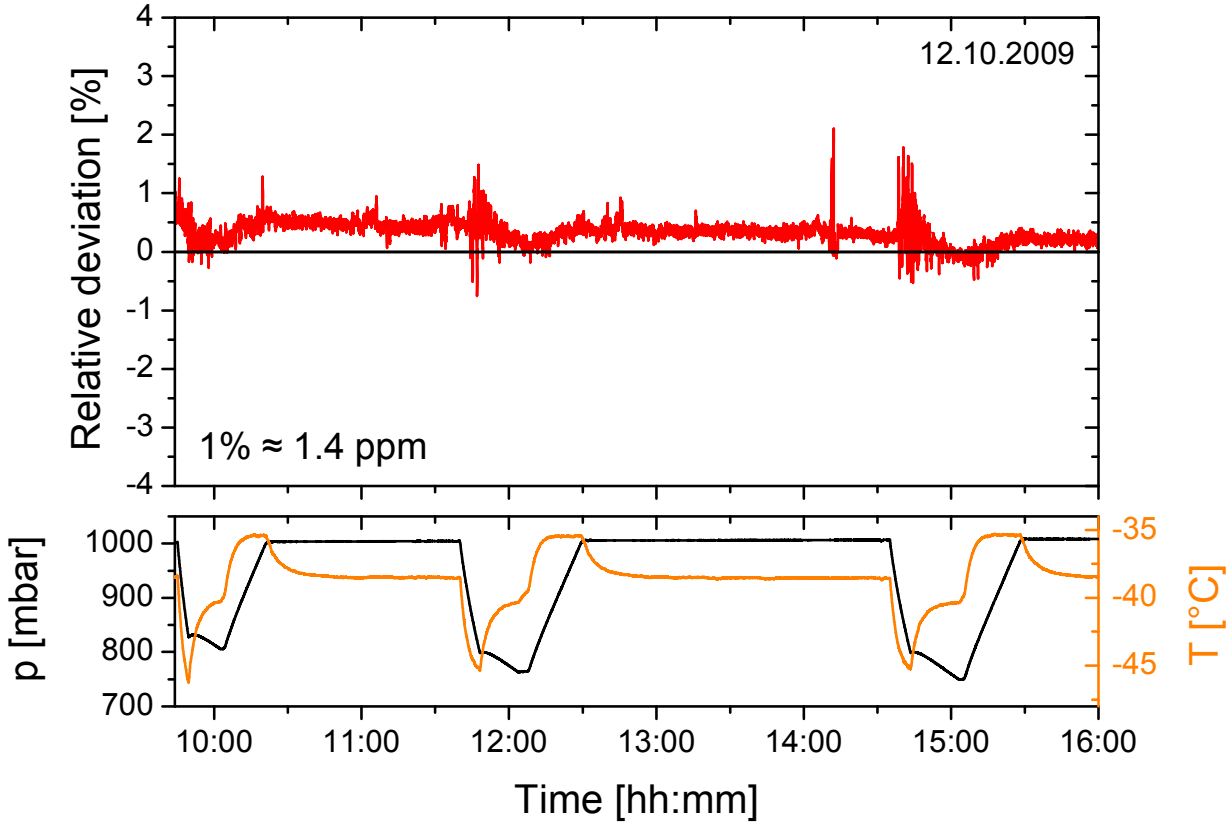
- Very good signal robustness of SP-APicT during ice cloud phases compared to APicT (signal loss factor 3-4 lower)
- Difference in transmission corresponds to a calculated length ratio of 6 (real ratio 5)

Intercomparison SP-APicT vs. APicT



- Excellent agreement between SP-APicT and APicT (independent instruments, no scaling of data)

Intercomparison SP-APicT vs. APicT



- Excellent agreement between SP-APicT and APicT (independent instruments, no scaling of data)
- Small deviations during ice cloud phases

TDL performance 1.4 µm

	Opt. path	Dynamic range	Resolution	Application
APicT	23-99 m	<1-2000 ppm	15 ppb -100 °C FP	Cold clouds
SP-APicT	~ 4 m	10-12000 ppm	~250 ppb -85 °C FP	Warm, dense clouds
APeT	~ 30 m	<1-1500 ppm	25 ppb -97 °C FP	Total water

Advantages of SP-APicT:

- Six times higher upper limit of dynamic range compared to APicT
- Measurement in denser clouds possible

Application to cloud microphysics

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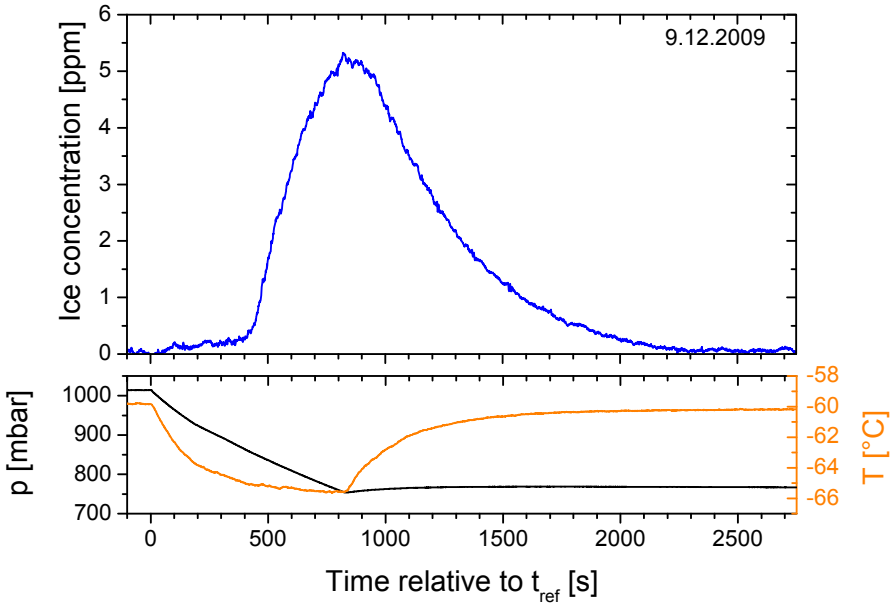
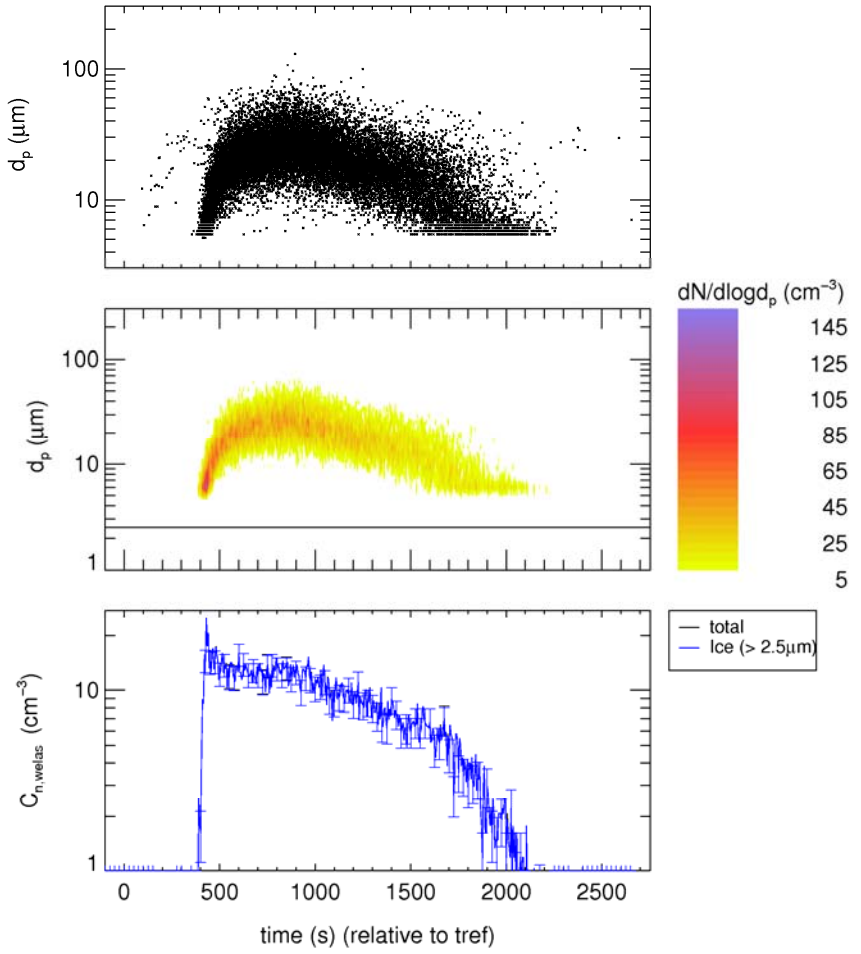
TABLE II: Known Condensation Coefficient Measurements versus Temperature Using Direct Condensation Techniques

α	temp range, K	method	ref
unity	213–233	gravimetric	3
0.83 ± 0.15	133–158	gravimetric	5
0.06	193–223	ice crystal radial growth	11
$0.1 < \alpha < 0.50$	163–183	ice crystal radial growth	11
0.026	295–298	droplet radial growth	19
0.033	188–213	droplet radial growth	7
0.98	293	vapor loss	22
$0.8 < \alpha < 0.99$	138–152	gravimetric	36
$0.7 < \alpha <$ unity	280	vapor loss	8
0.04	293	liquid film growth	37
0.3 (+0.7, −0.1)	200	vapor flow loss	9
1.0 ± 0.1	150	IR absorption	38

D. R. Haynes, N. J. Tro, and S. M. George, J. Phys. Chem. **1992**, 96,8502-8509

First results (work in progress)





Summary & Outlook

- **Instrumental progress:**
  - Direct attachment of the APicT-optics to AIDA ⇒ higher accuracy
  - SP-APicT extends dynamic range to higher water vapor concentrations and allows measurements in dense clouds
- **TDL measurements** are applied to the determination of the **accommodation coefficient** of water molecules on ice
  ⇒ further modeling work necessary
- **Outlook:**
  - Validation of the extractive TDL (APeT) at the PTB with primary humidity standard of Germany
  - 2.6 µm TDLs for higher sensitivity/resolution (sub ppb)

Acknowledgements

- Ottmar Möhler and the entire AIDA team
- Technical staff at IMK-AAF
- Workshops at PCI and IMK
- Steven Wagner (PCI/TUD, Software)