Absolute TDL Hygrometers for AIDA: Present and Future

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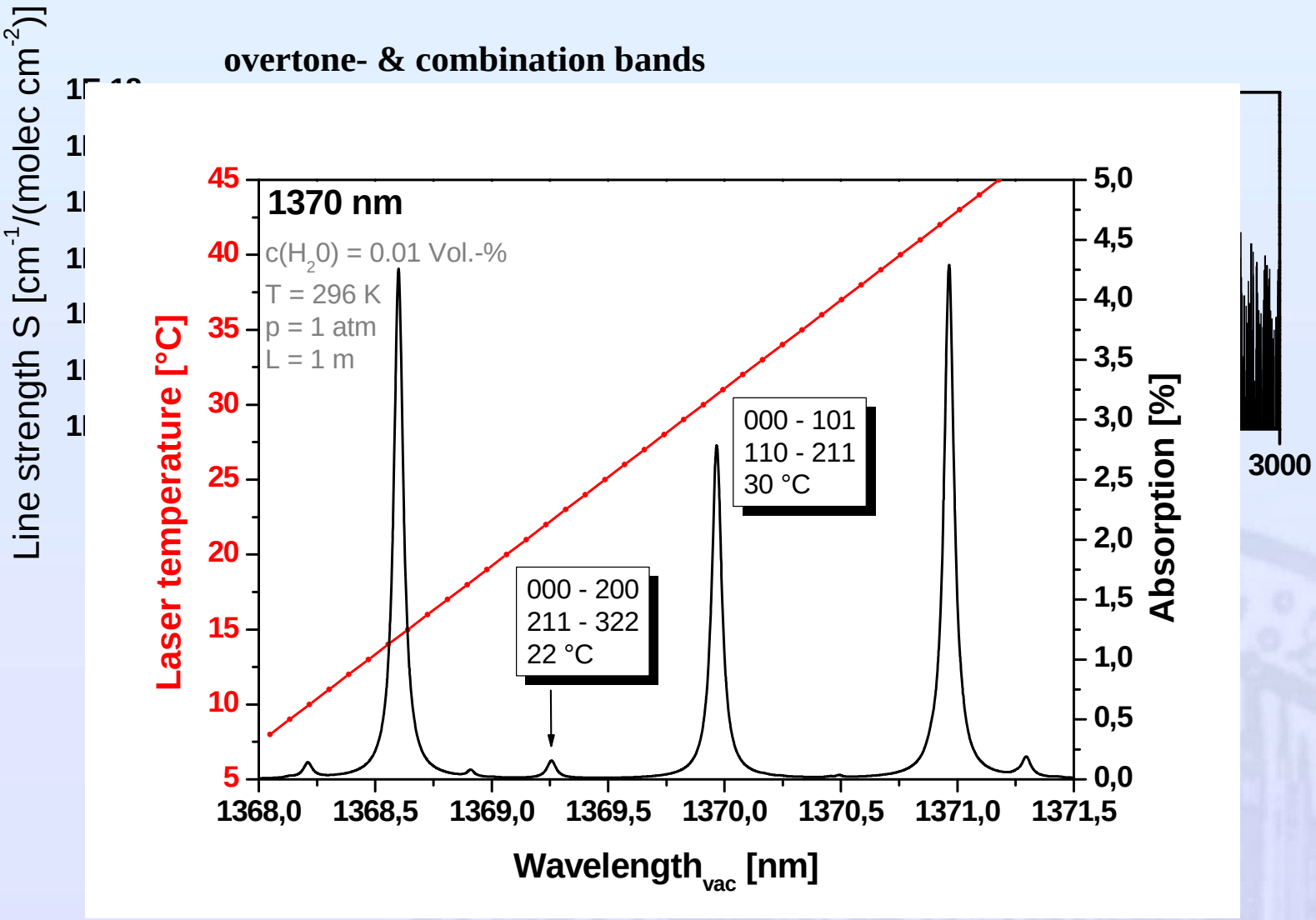
Outline

- AIDA TDL overview
- Brief introduction to TDLAS
- Performance of present TDLs
- Goals for future TDLs
- Performance of present and future TDLs compared
- Summary

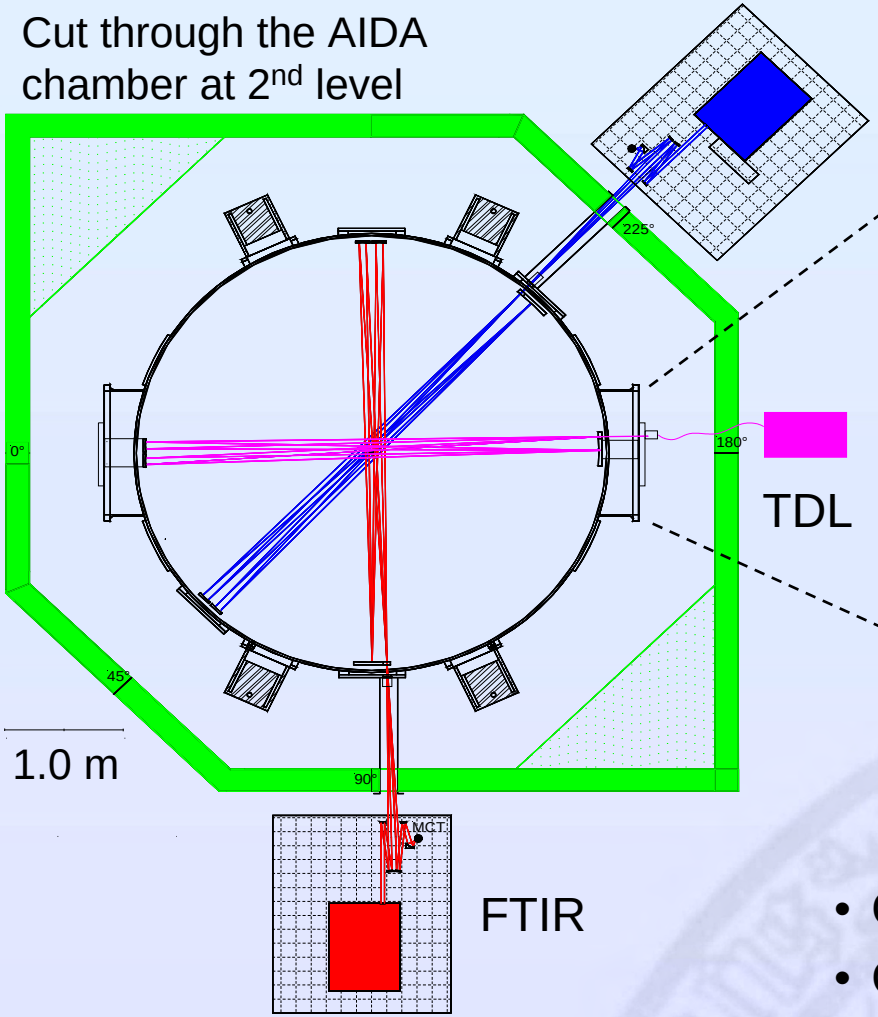
AIDA TDL overview

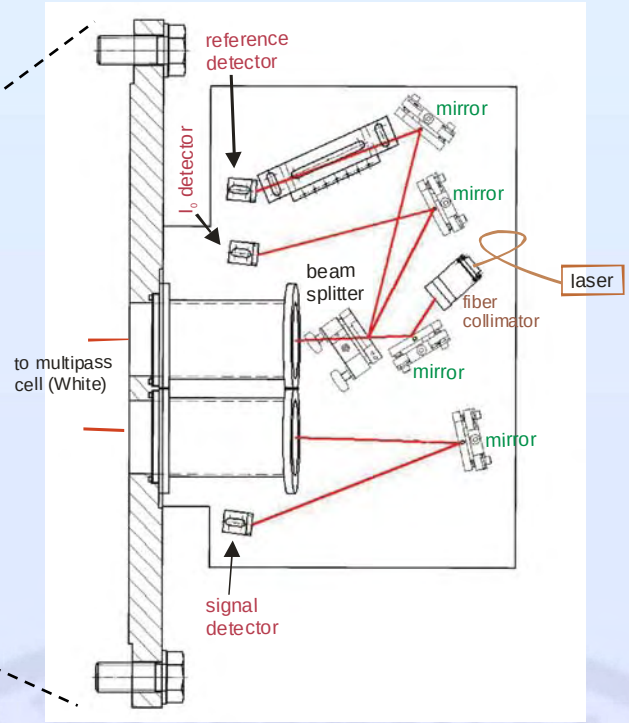
- **In situ measurement of water vapor:**
  - Open path white cell with TDL absorption spectrometer (APicT)
  - New: Single path TDL (SP-APicT) for high concentrations
- **Measurement of total water**
  - Extractive TDL absorption spectrometer (APeT)
    Sampling via heated (30 °C) stainless steel tubes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

Ro-Vibrational Spectrum of Water Vapor



In situ TDL (APicT) adaptation to AIDA



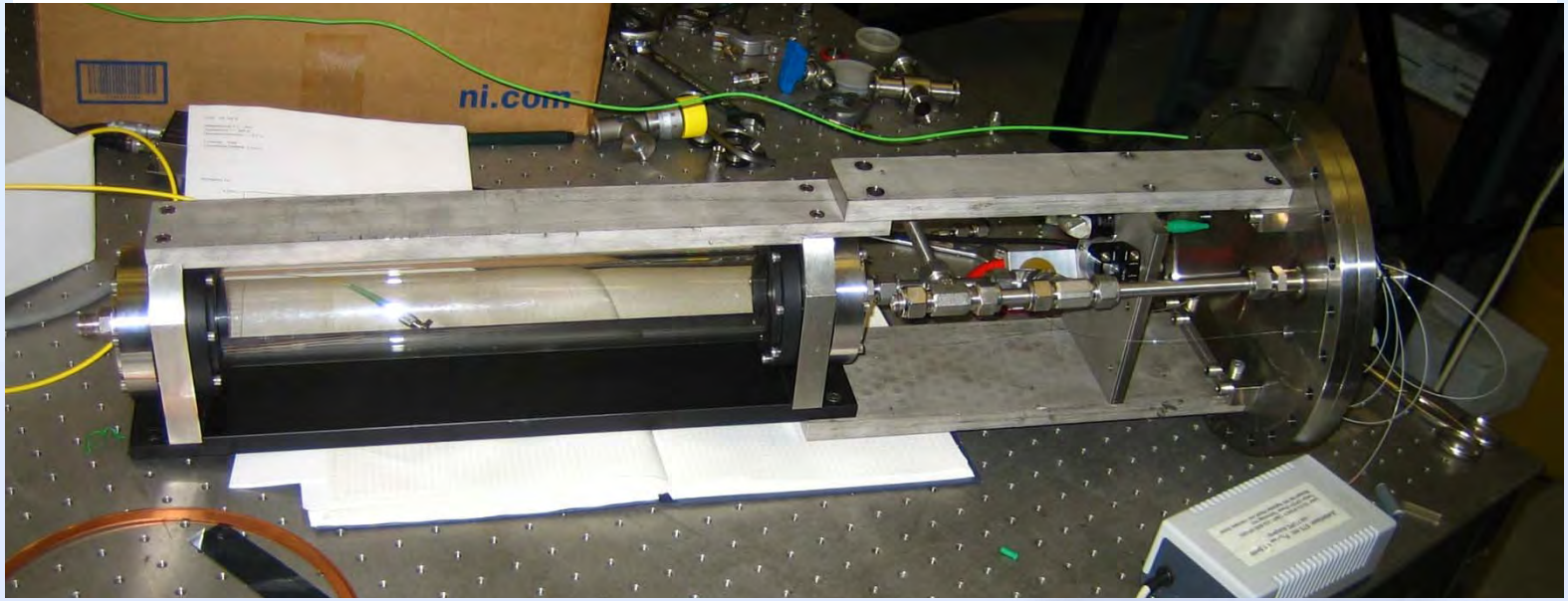


- Open path White cell
- Optical path length: 23 to 99 m
- Fiber coupled transfer optics outside the AIDA chamber ⇒ parasitic absorption

Technisches Messen 72, 1, 23-30 (2005)

J. Geophys. Res. 110, D11210, (2005)

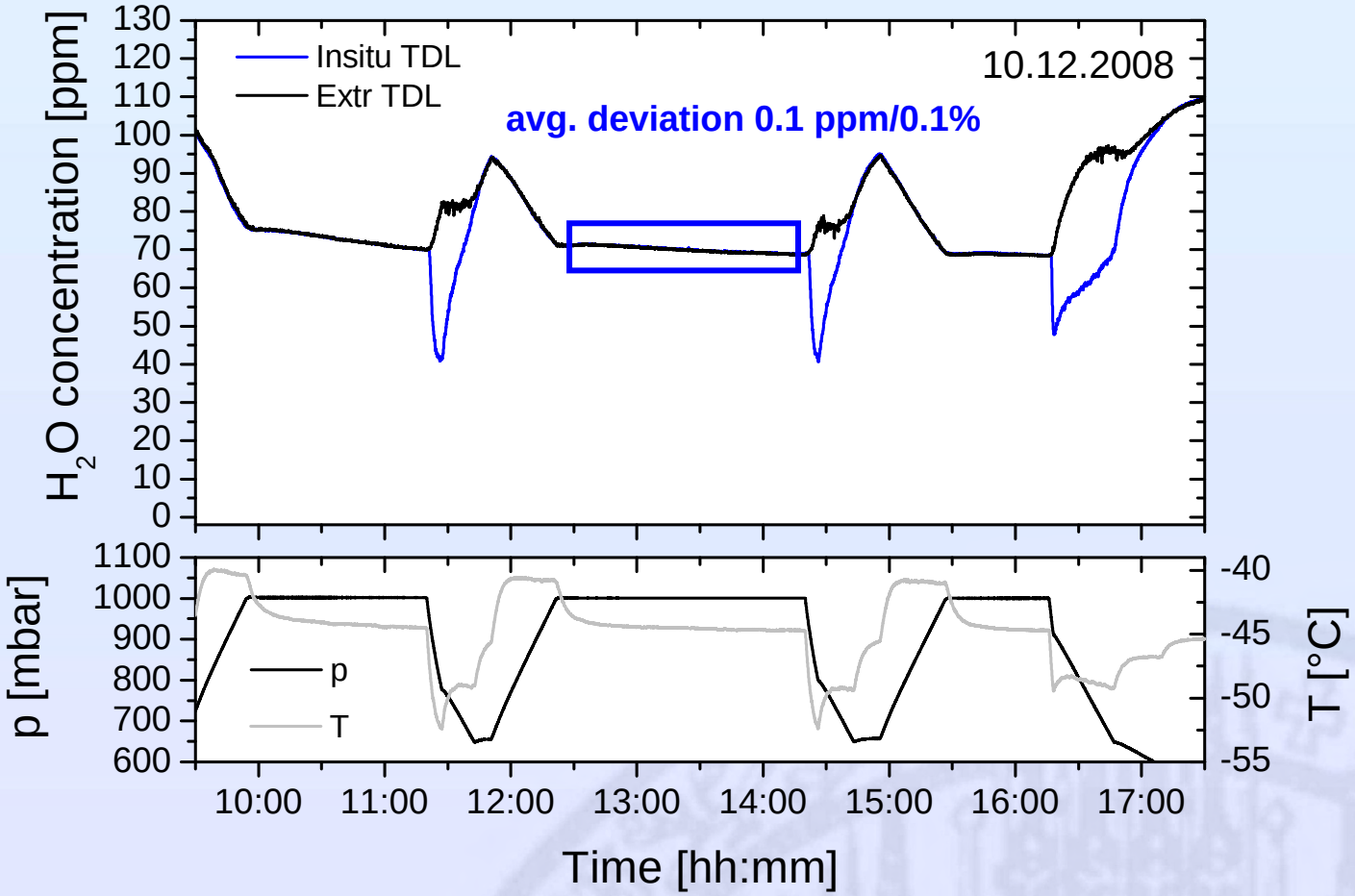
Extractive TDL (APeT)



- Multipath cell (Herriott type)
- Optical path length: 30.3 m
- Fiber coupled transfer optics
- Instrument housed in a purged vacuum vessel

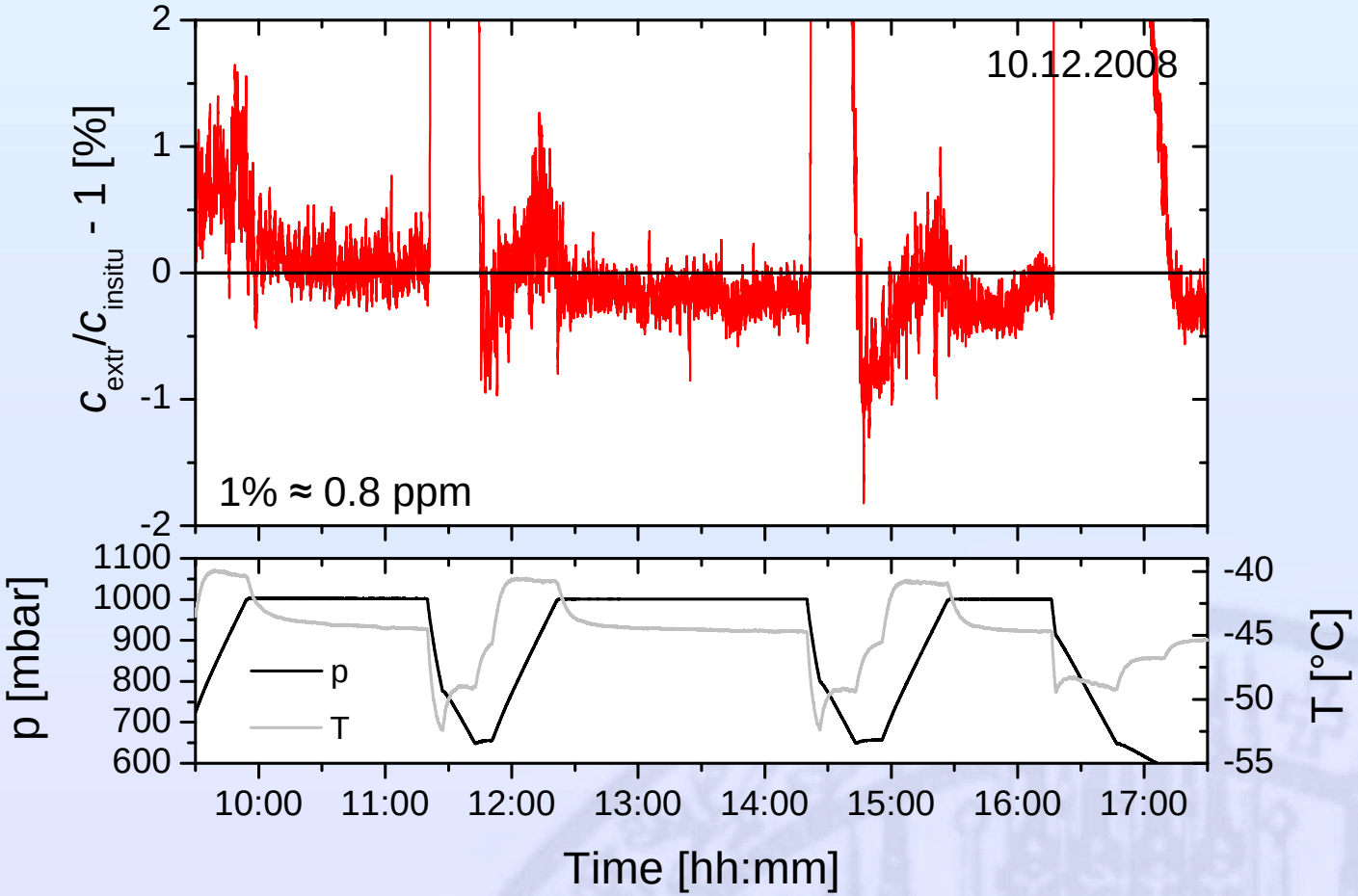
  $\Rightarrow$ Minimal parasitic absorption (ambient air)

APicT & APeT results



- Very good agreement between both TDLs (no matching of data)
- no data scaling, no calibration

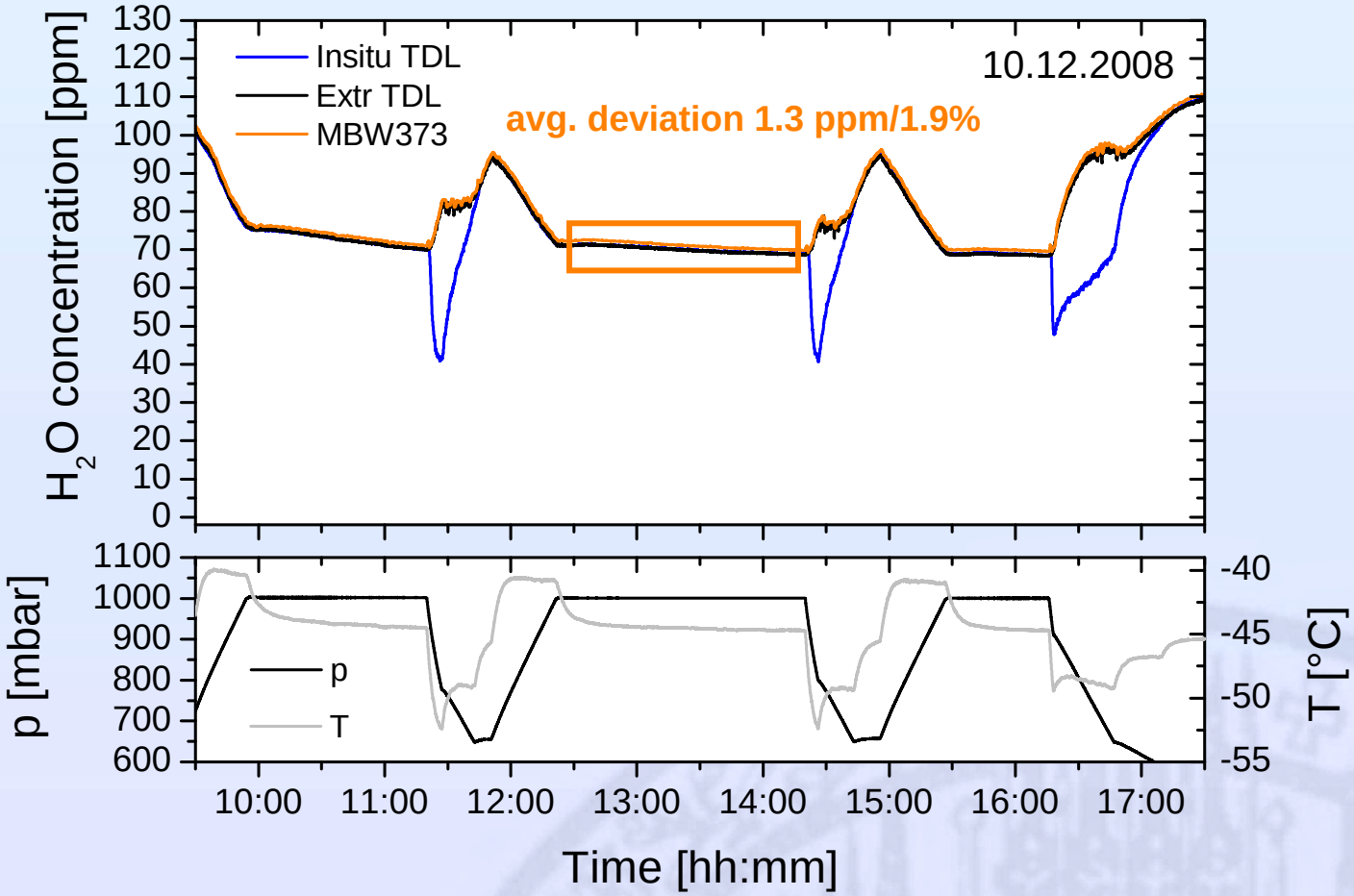
Deviation between APicT and APeT



- Small deviation between both TDLs (absolute and relative)
- Slight overall shift over time
- Larger deviations during contraction period

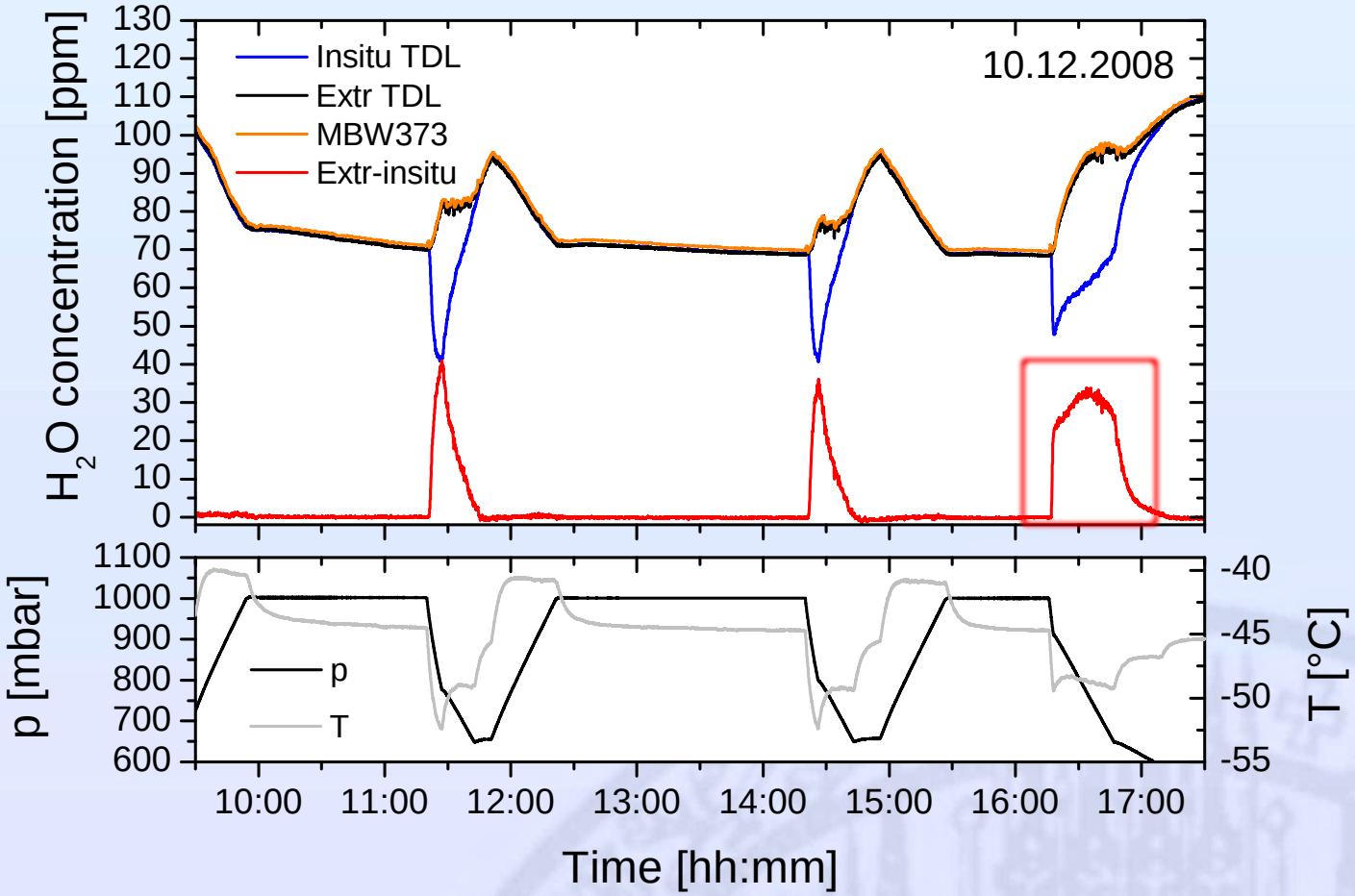
} reason under investigation

APicT & APeT results



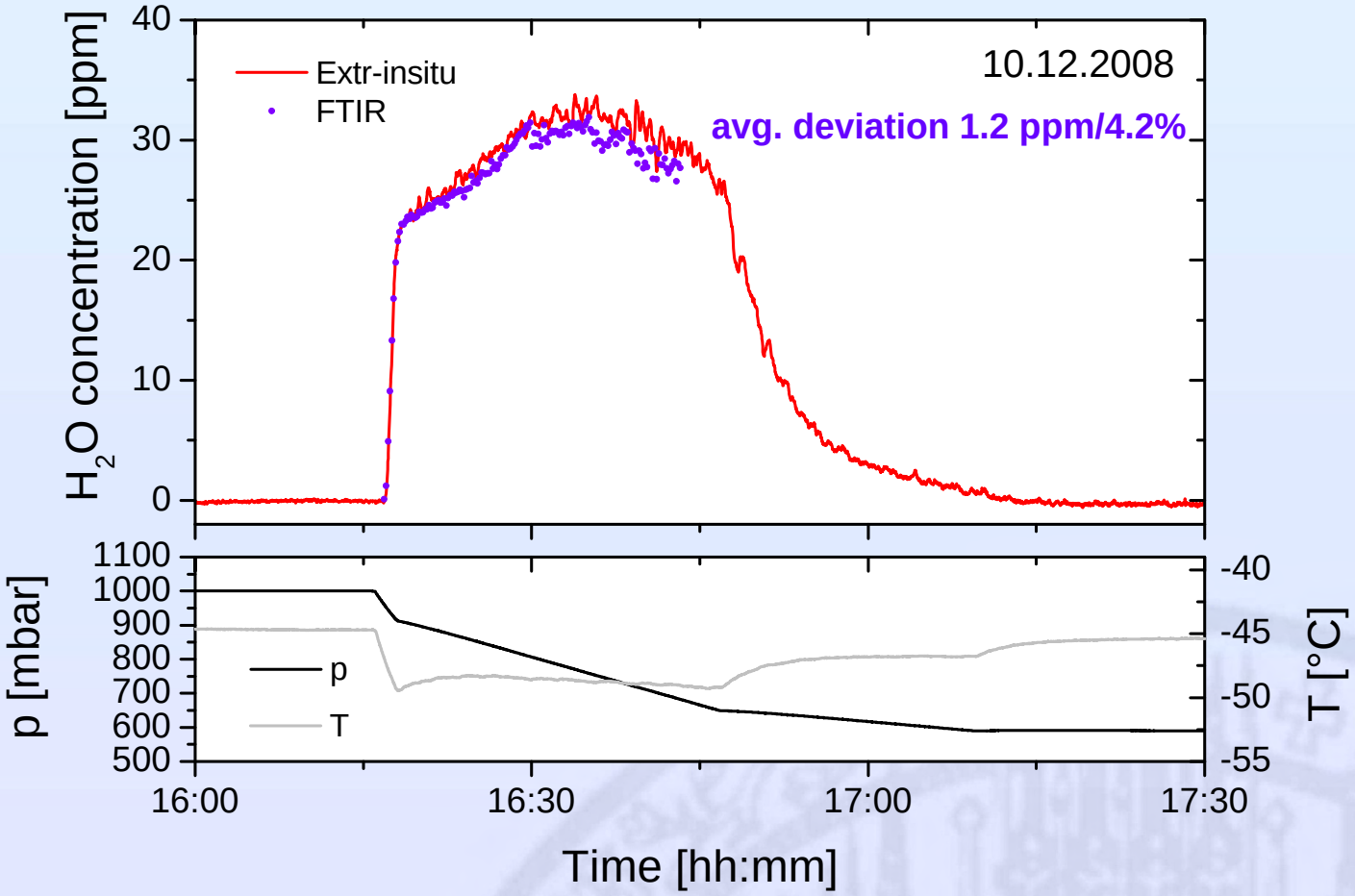
- Good agreement between APeT and MBW

APicT & APeT results



- Advantage of dual TDL system:
  directly comparable results – independent of external conditions

APicT & APeT results



- Good agreement between TDL difference and FTIR

  FTIR: R. Wagner et al Atmos. Chem. Phys. 6, 4775 (2006)

Goals for the future

- **Increase of dynamic range**

  APicT: 1-5000 ppm at present

  APeT: 1-1000 ppm at present

- **Increase of resolution**

  APicT: 25 ppb (-97°C FP) at present

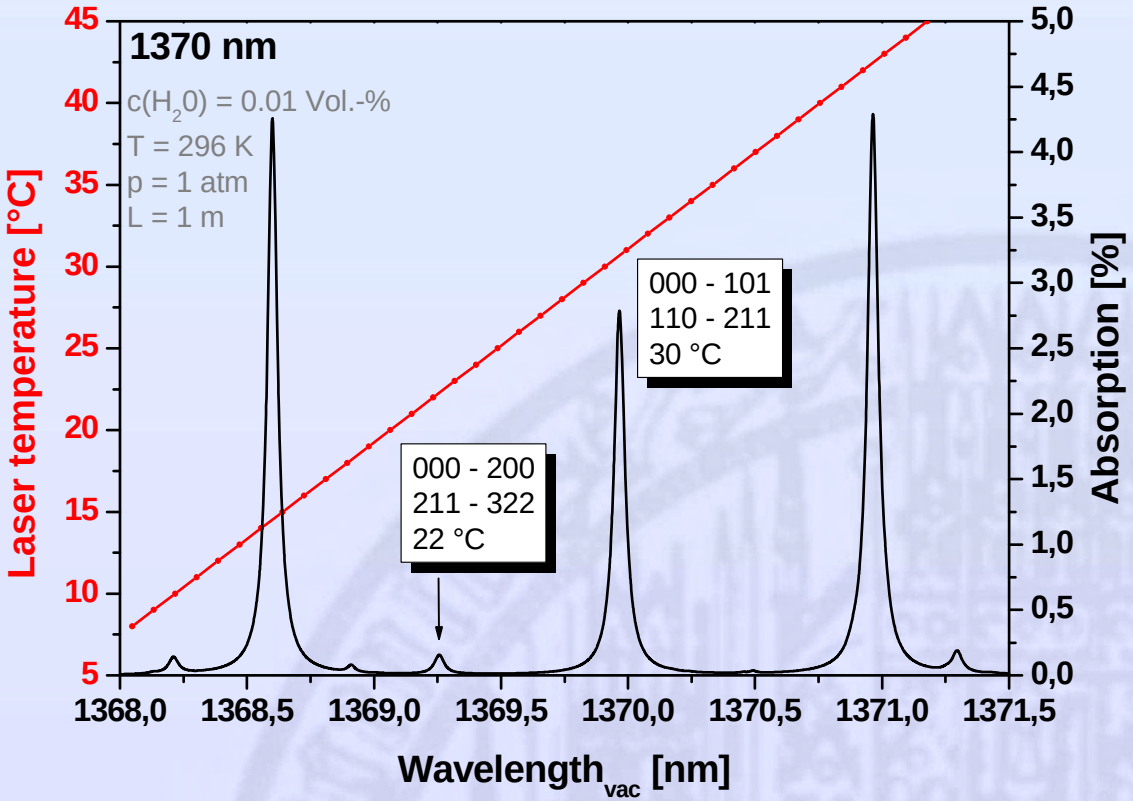
  APeT: 25 ppb (-97°C FP) at present

- **Increase of absolute accuracy**

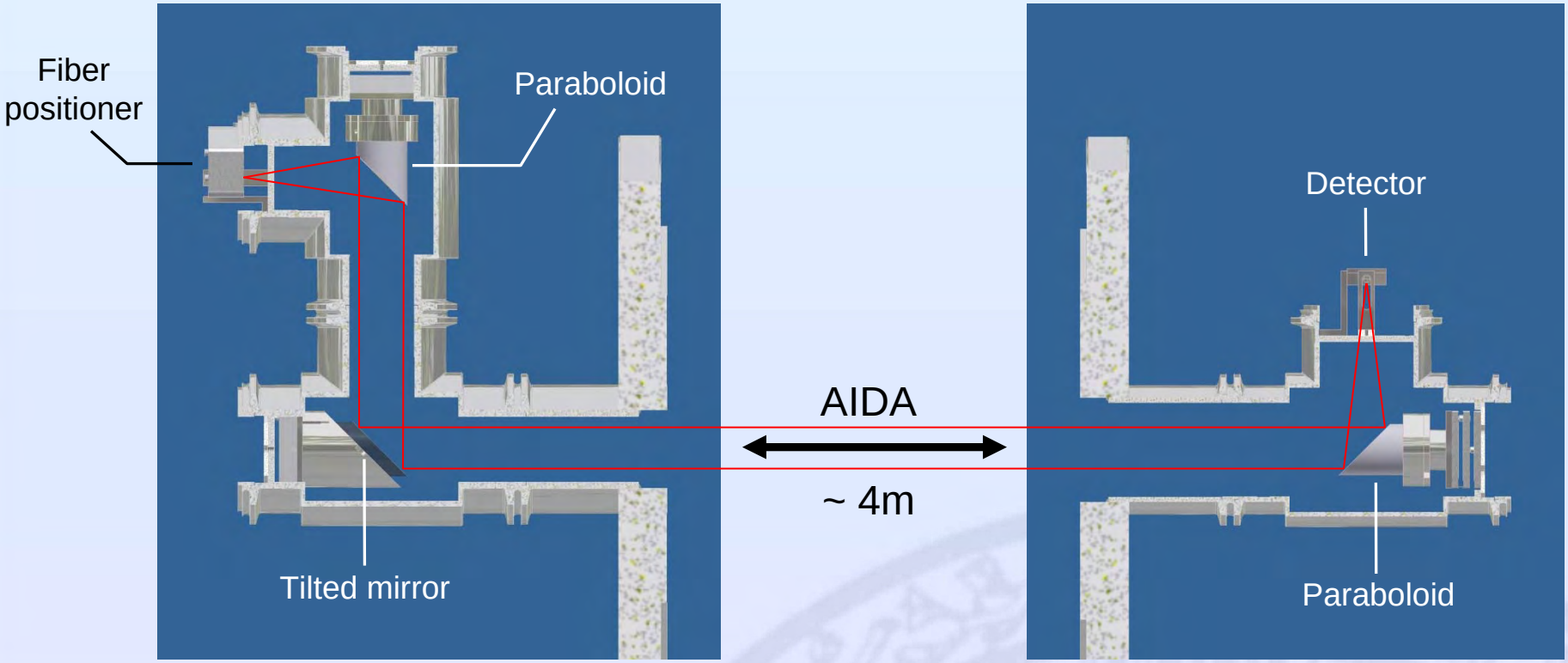
Increase of dynamic range

Two possibilities for high water vapor concentrations

- Go to weaker absorption line ⇒ strong interference with adjacent lines
- Reduce optical path length ⇒ SP-APicT
  Additional advantage: lower scattering losses ⇒ denser clouds

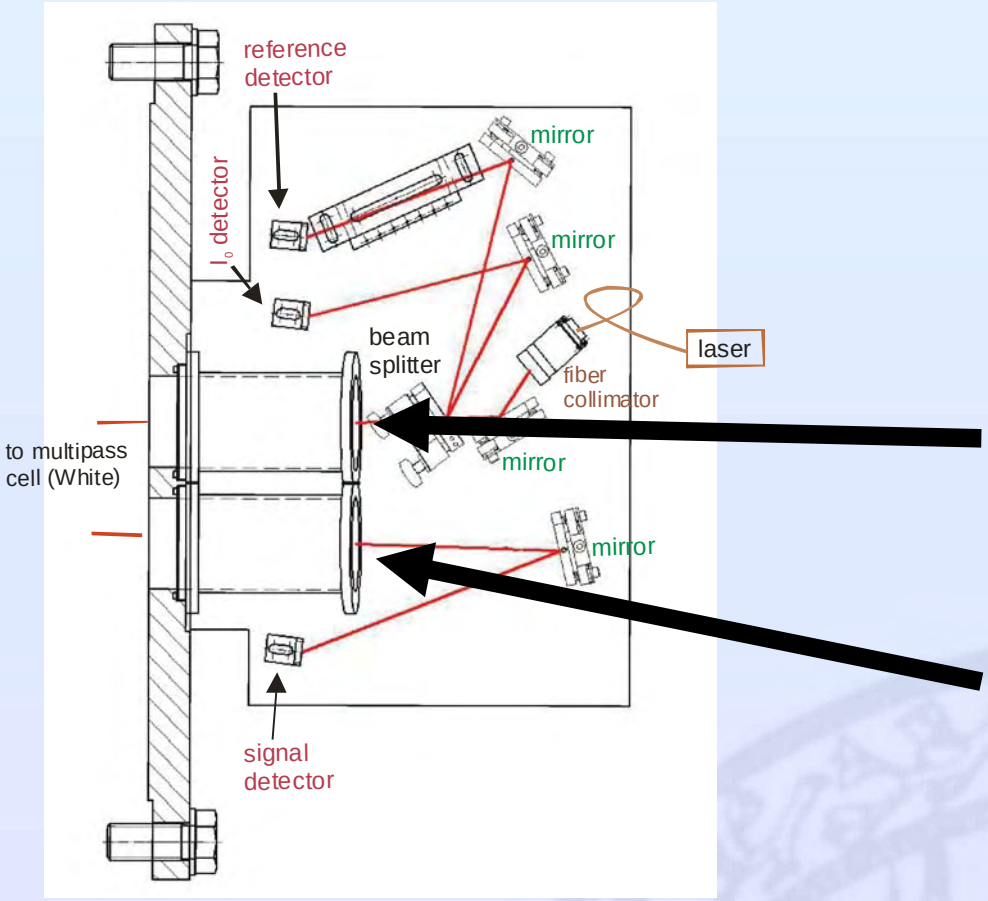


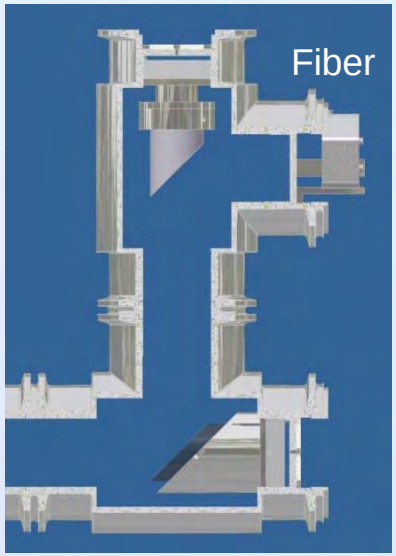
Single-path APicT

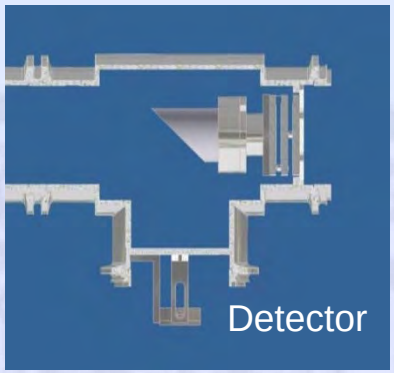


- Optical path length: ~ 5m
- Fiber coupled, optics inside AIDA chamber, purged with AIDA air
- Minimal parasitic absorption

Application to in situ TDL (APicT)







- Parasitic absorption ⇒ corrections necessary for concentrations <1 ppm
- Quite straight forward replacement of existing optics

⇒ **Increase of absolute accuracy for low water vapor concentrations**

APicT performance comparison 1.4 µm

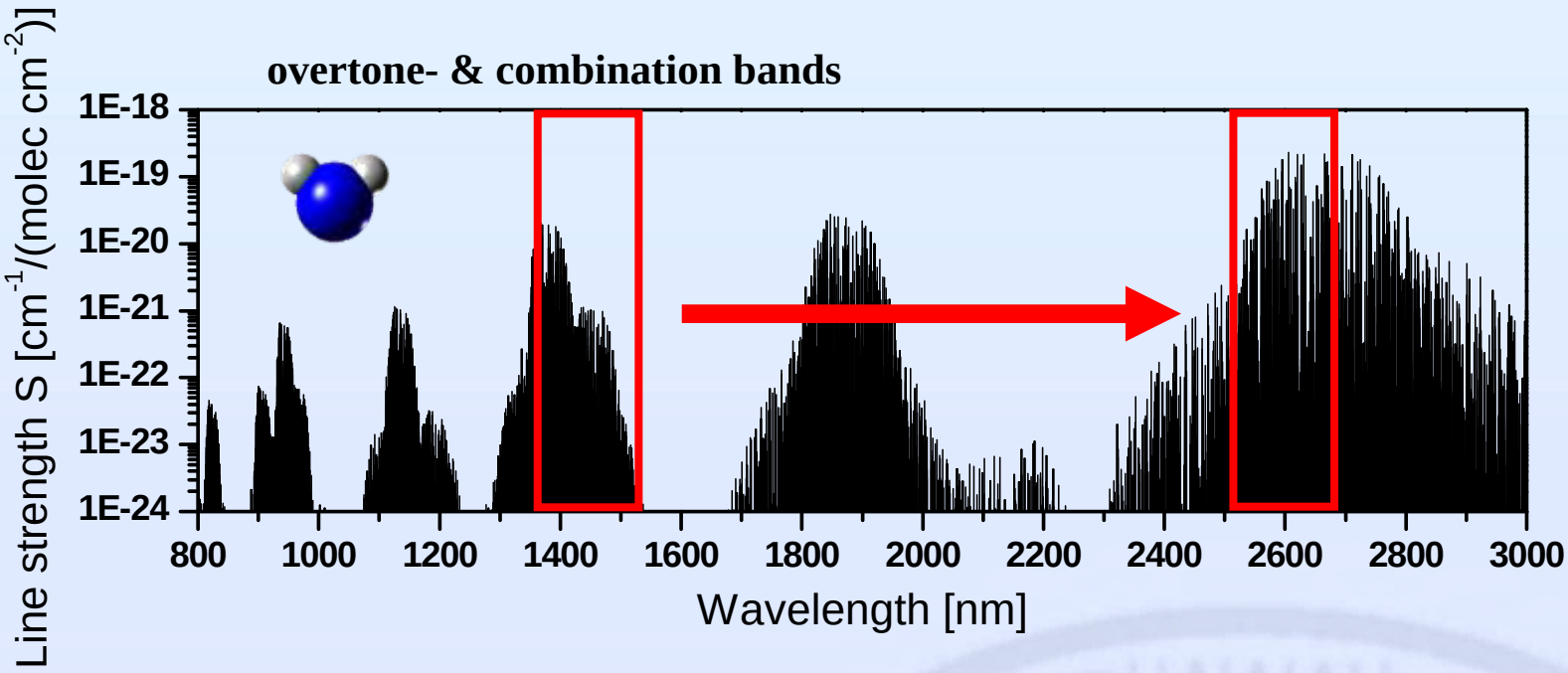
	Optical path	Dynamic range	Resolution	Time resolution
APicT (30 °C)	23-99 m	<1-1000 ppm	25 ppb -97 °C FP	1-2 s
APicT (22 °C)	23-99 m	10-5000 ppm	500 ppb -80 °C FP	1-2 s
SP-APicT (30 °C)	~ 5 m	10-7500* ppm	250* ppb -85 °C FP	1-2 s

* tbd.

Advantages of SP-APicT:

- 50% increase of upper dynamic range limit with SP-APicT
- no problems with 22°C absorption line any more
  $\Rightarrow$ higher accuracy
- shorter optical path allows denser clouds

Outlook: increase in sensitivity



- 20 times stronger absorption lines
- 20 times higher sensitivity

Critical components: lasers, detectors, optical fibers etc.

solved — in progress

TDL performance comparison 1.4 & 2.6 µm

	Optical path	Dynamic range	Resolution	Application
APicT (1.4 µm)	23-99 m	<1-1000 ppm	25 ppb -97 °C FP	Cold clouds
APicT (2.6 µm)	23-99 m	<0.1-50* ppm	1.3* ppb -111 °C FP	Very cold clouds
SP-APicT (1.4 µm)	~ 5 m	10-7500* ppm	250* ppb -85 °C FP	Warm, dense clouds
SP-APicT (2.6 µm)	~ 5 m	<1-400* ppm	13* ppb -100 °C FP	Cold, dense clouds

Planned configuration

* tbd.

Overall performance of planned insitu configuration

- Dynamic range: <0.1-7500 ppm
- Resolution: 1.3 ppb

Similar extension planned for APeT

Summary

- **Present APicT and APeT give very good results, in agreement with other instruments**
- **SP-APicT expands dynamic range to higher water vapor concentrations and allows measurements in very dense clouds**
- **SP-APicT coupling optics can be applied to APicT**
  ⇒ higher accuracy (minimal parasitic absorption)
- **Introducion of 2.6 µm diode lasers**
  ⇒ 20 times higher resolution and increased dynamic range
  ⇒ better data for very cold clouds (< -80 °C)
- **Planned APicT configurations cover a large dynamic range and a wide variety of different cloud types**