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HCI CEM: “Best Practices” and Technology

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- Experience
- Best Practices
- NDIR – Gas Filter Correlation
- Tunable Diode Laser Spectroscopy – TDLS
- Fourier Transform IR – FTIR
- Discussion / Questions

Experience

- SICK, Inc. has over 30 Years experience measuring HCl in CEM applications
  - Cement
  - Power
  - Waste Incineration
  - Pharmaceutical

- SICK has over 50 HCl CEM's installed in the US today, and more than 2500 units delivered world wide.

- Typical spans are in the 0 - 5/10ppm range

Best Practice

- Rapid and accurate measurement of HCl in ppm concentrations can only be made when measured wet.
  - This prevents errors due to absorption and desorption effects from HCl on wetted parts.
- The entire sample train must be kept hot and insulated to prevent cold spots
  - System components should be kept at a minimum of 185° C to prevent cold spots
    - Swagelok fittings, high quality heated sample pump
    - Flange and tube at the sample probe with ends of sample line extended from heated line and insulated
    - Vent tube from photometer to avoid salt formation and sample probe tube if flue gas is below acid dewpoint
- Sample at high temperature **and high flow rate**
  - Shortens the time that the sample is in contact with the system components minimizing memory effects

Best Practice

- Unlike most gases, calibration gas injection is the most troublesome part of HCl monitoring.

  - Dry calibration gas injection at the probe leads to issues with absorption/desorption
  - Measurement stability time of the system can be very long (>35-40 min at <10ppm)using a lot of expensive cal gas
  - This issue is not specific to any measurement technology (NDIR, TDLS, FTIR)

- Certification testing must be properly managed

  - The sample has to be maintained above the acid dew point (normally 140-150 ^{o}C) up until it reaches the first impinger
  - Chlorides not removed in the particulate filter can cause interference problems in the HCl measurement

Best Practices - Calibration

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: Keep Calibration gas cylinders and associated hardware dry

- Cylinders are available in the range of 0-10ppm
- Cylinders should be aluminum only
- Keep moisture from mixing with the calibration gas
- N2 purge on the pressure side is recommended so that ambient H2O does not mix with the gas
- Pressure regulators must be stainless steel
- Always use PTFE sample lines

Best Practices - Calibration

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- Options
  - Daily calibrations for both in situ and extractive monitors can be done with internal span filters.
    - CGA Audit services can be done with a wet calibrator, a European standard
  - Automated wet calibrator can be integrated into the system.
    - Significant reduction in memory effects
    - Can add up to $40k to system cost, but payback is immediate.
  - “Season the sample line”
    - Use 2nd bottle of HCl (high concentration) or pull stack gas through to wet the line between zero and span gas
    - Use a second cal gas valve necessary,

NDIR Monitoring Technique

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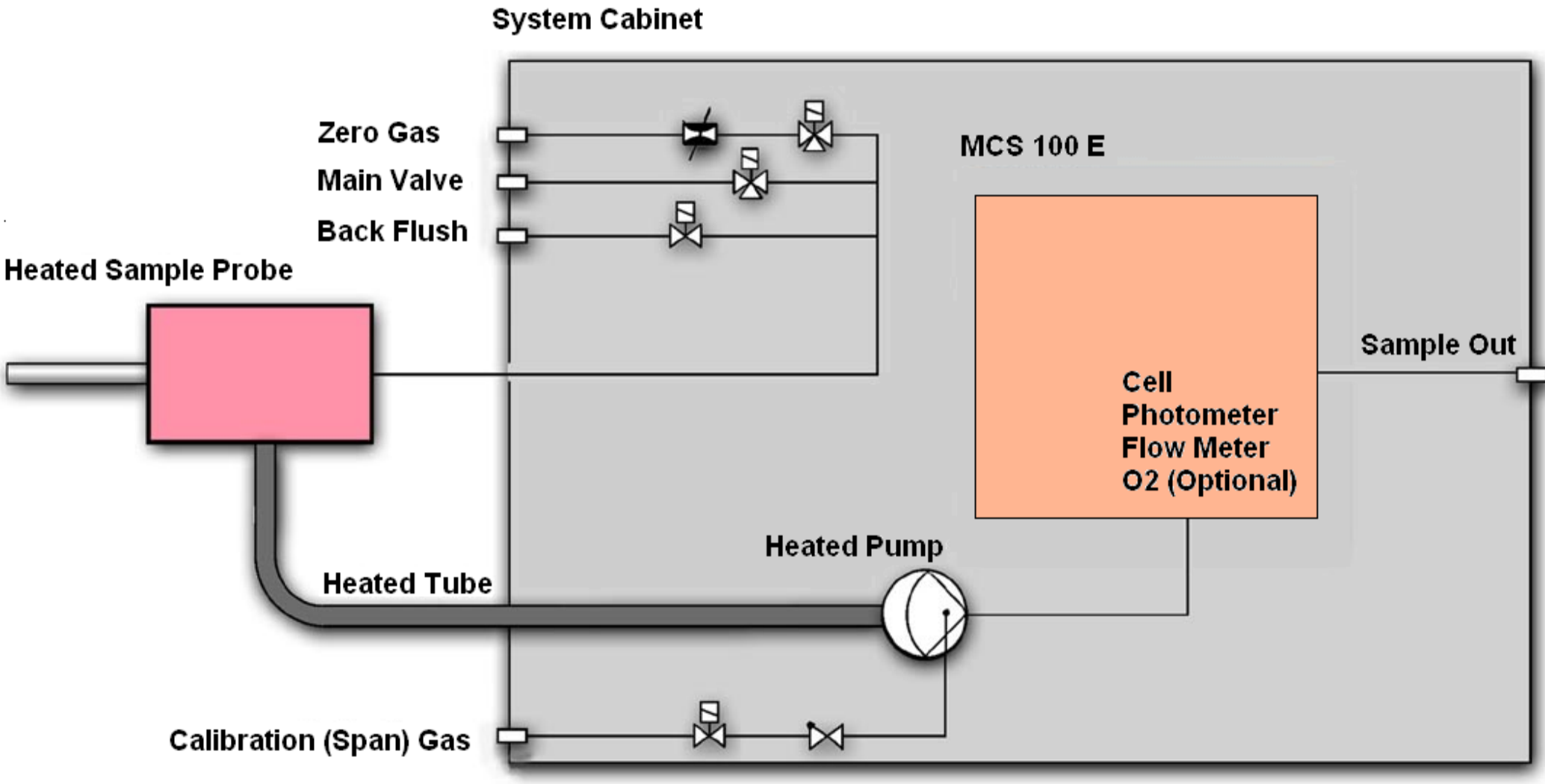
- Multi-component
- Undiluted Hot Wet Extractive
- Utilizes Gas Filter Correlation Technique for I
- Simple and reliable sample system
- Long path cell for low ranges
- > 2500 installations worldwide
  - >200 in the US (50 for HCl)

NDIR Monitoring Technique



NDIR Monitoring Technique

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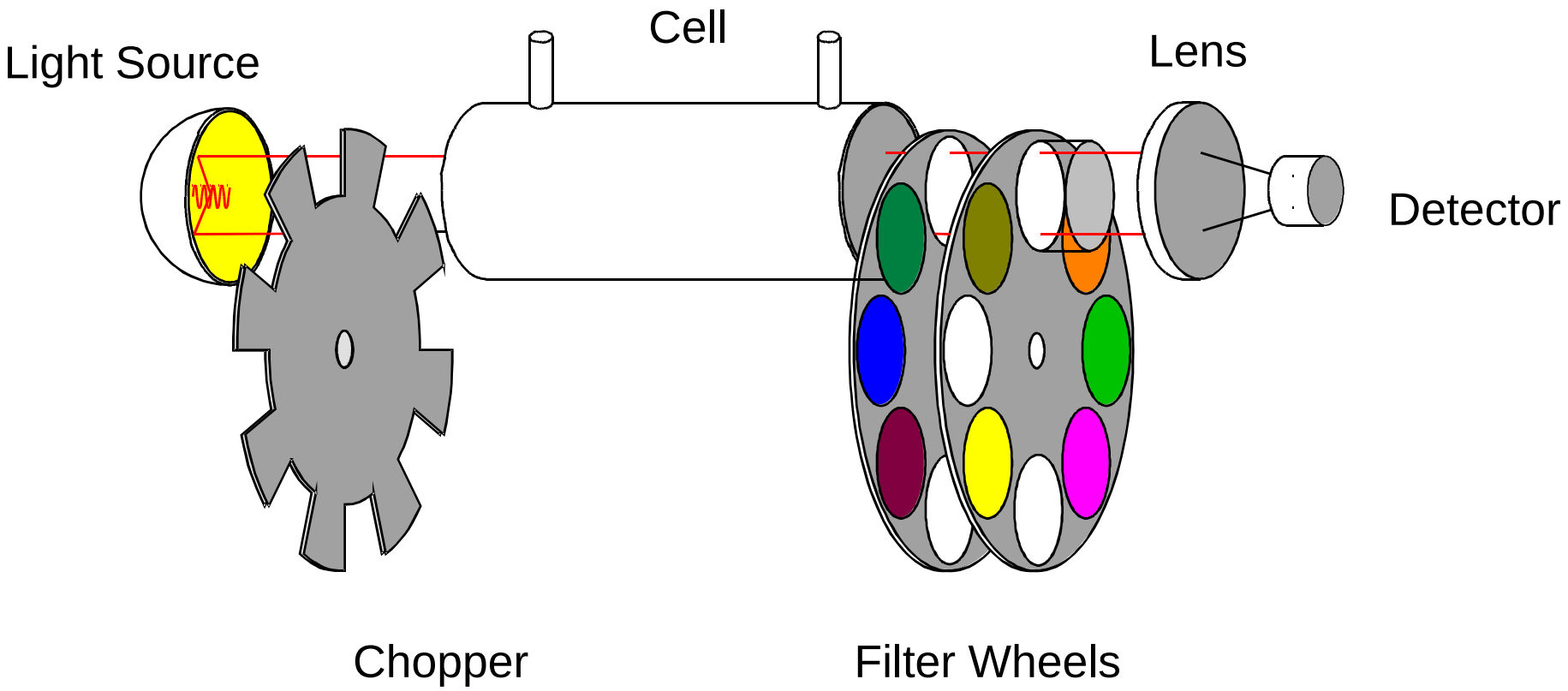
NDIR Measuring Principle



NDIR Monitoring Technique

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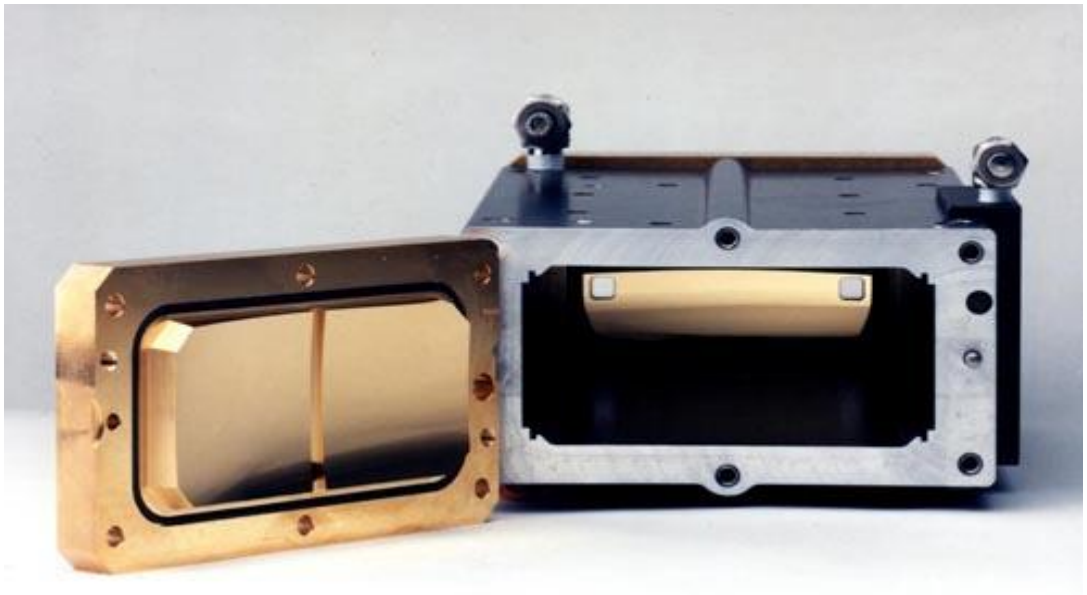
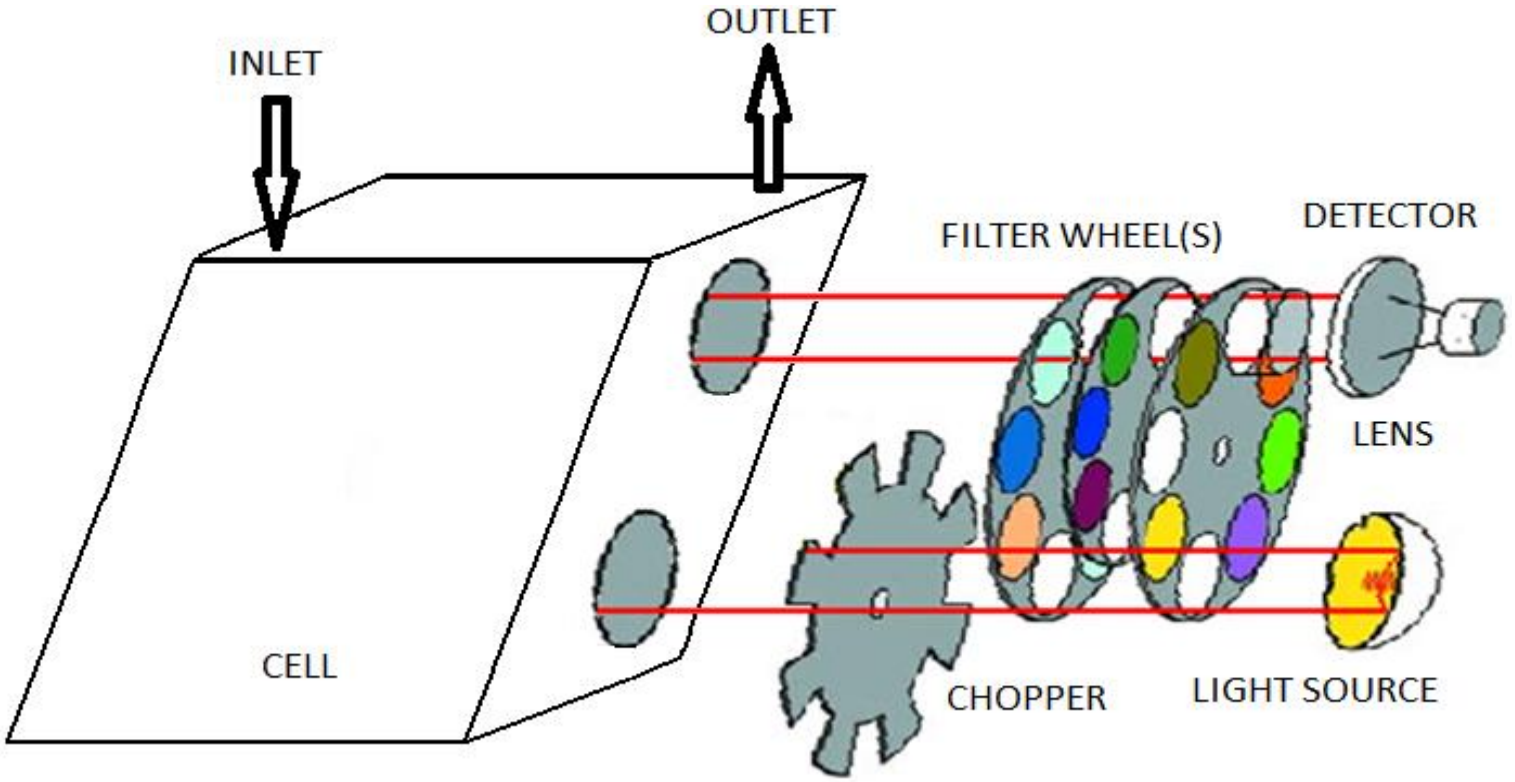
Long path cells for low ranges:

- Gold covered mirrors for optimal light intensity
- Special coating for corrosion resistance
- High mass for thermal stability
- Different optical path lengths available (20 ft is standard)



NDIR Monitoring Technique

Measuring Principle (actual configuration)



- Third filter wheel optional with up to 3 additional components or calibrations

NDIR Monitoring Technique

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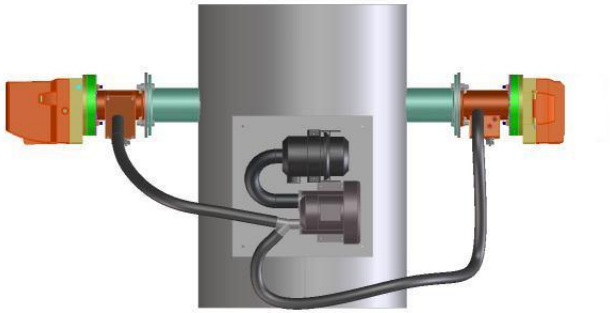
Relevant Measuring Ranges

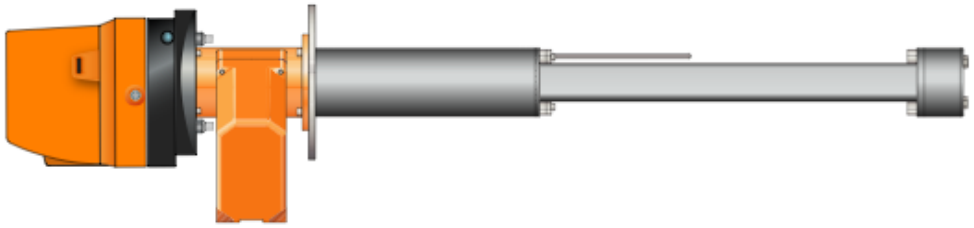
HCl	0	-	10	ppm
NH_3	0	-	15	ppm
SO_2	0	-	25	ppm
CO	0	-	40	ppm
NO	0	-	80	ppm
CO_2	0	-	25	Vol.-%
H_2O	0	-	40	Vol.-%
O_2	0	-	21	Vol.-%
NO_2	0	-	50	ppm
N_2O	0	-	50	ppm
CH_4	0	-	70	ppm

Smallest ranges @ standard conditions dry (H_2O, O_2: wet)

TDL Monitoring Technique

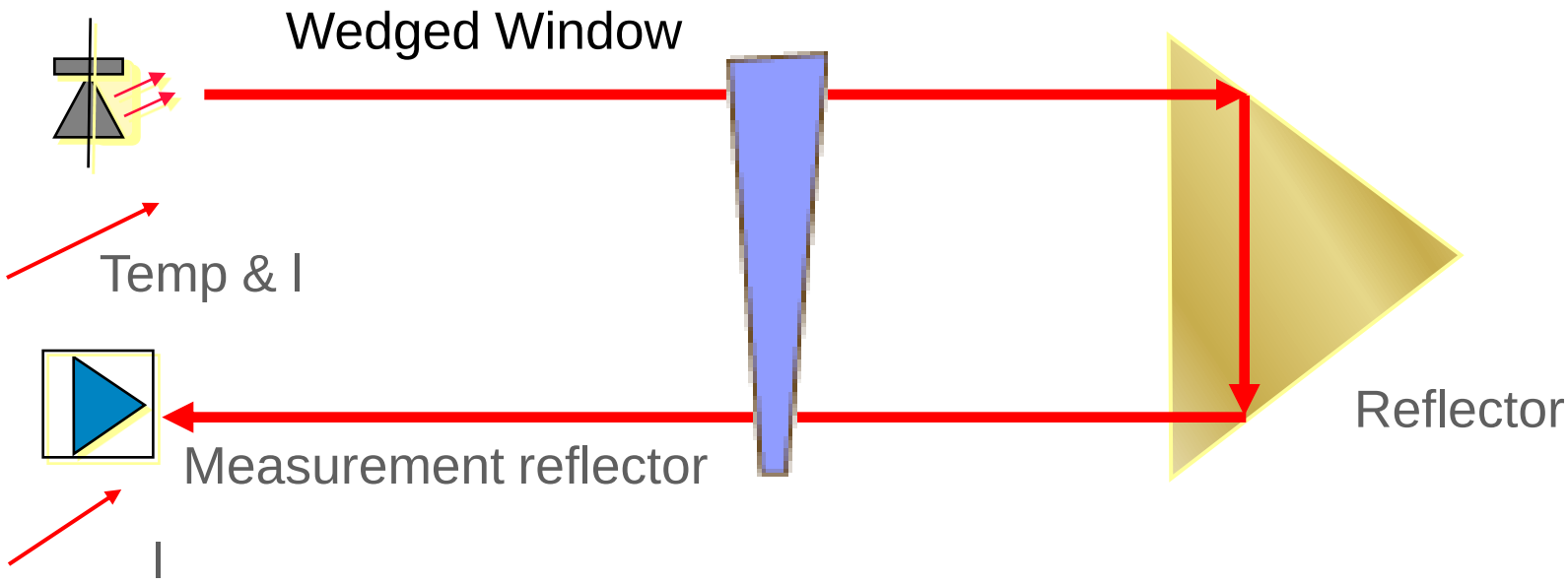
- Tunable Diode Laser Spectrocopy uses a laser light scanning over a specific absorption wavelength area of the desired measurement component.
- Laser selectivity means high sensitivity and minimal cross interference effects
- “Line locking” technique eliminates measurement drift
- Internal gas filled cell can be used for daily validation
- Available in in-situ and extractive configurations
  - In-situ: Cross stack and probe
  - Extractive: Hot wet





TDL Monitoring Technique

Measuring Channel without Gas Component



The temperature of the laser diode is changing due to a steady increase of the input current (ramp).

Together with the temperature of the laser, the wavelength output changes as well.

TDL Monitoring Technique

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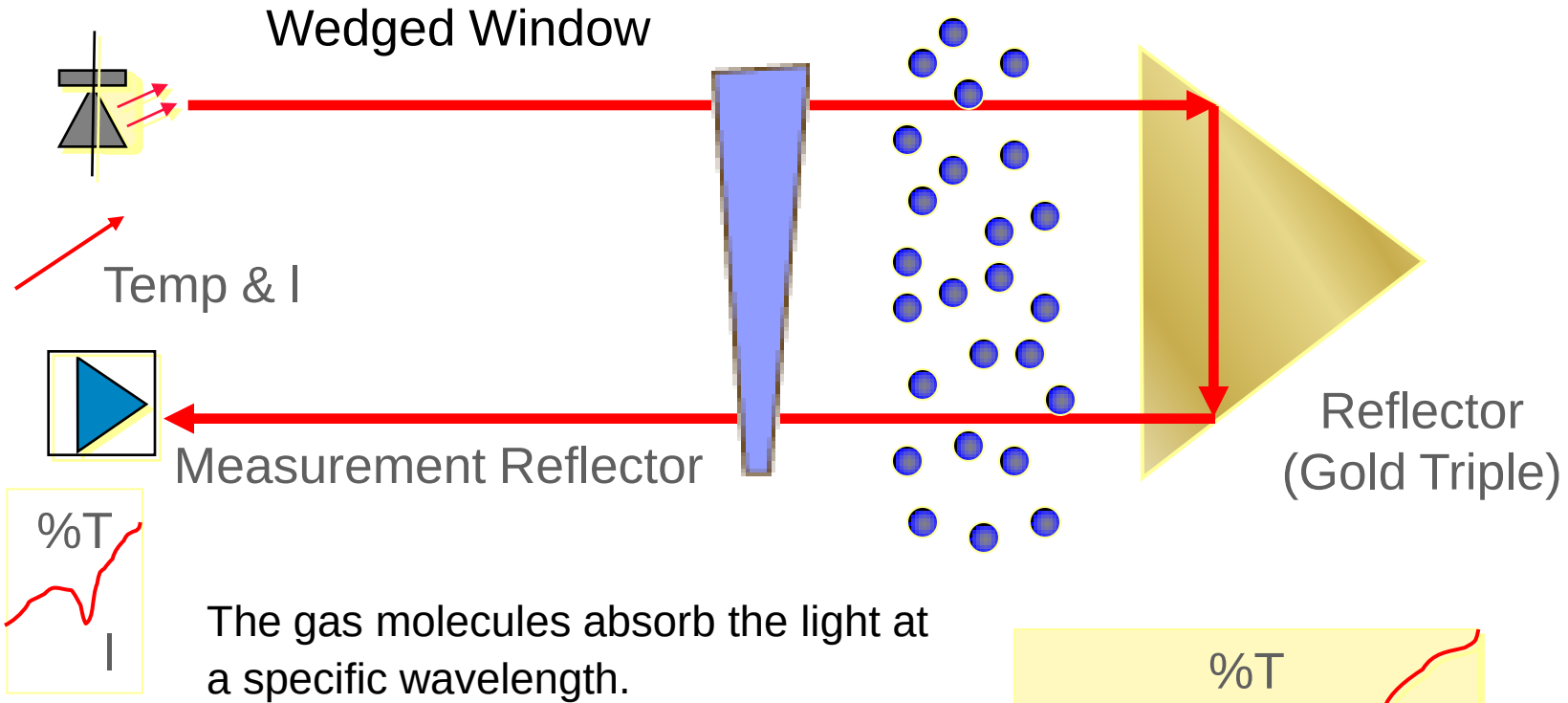
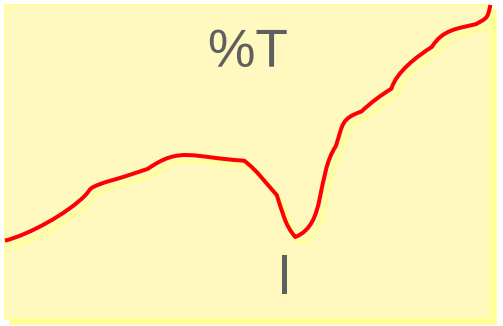
Measuring Channel with Gas Component



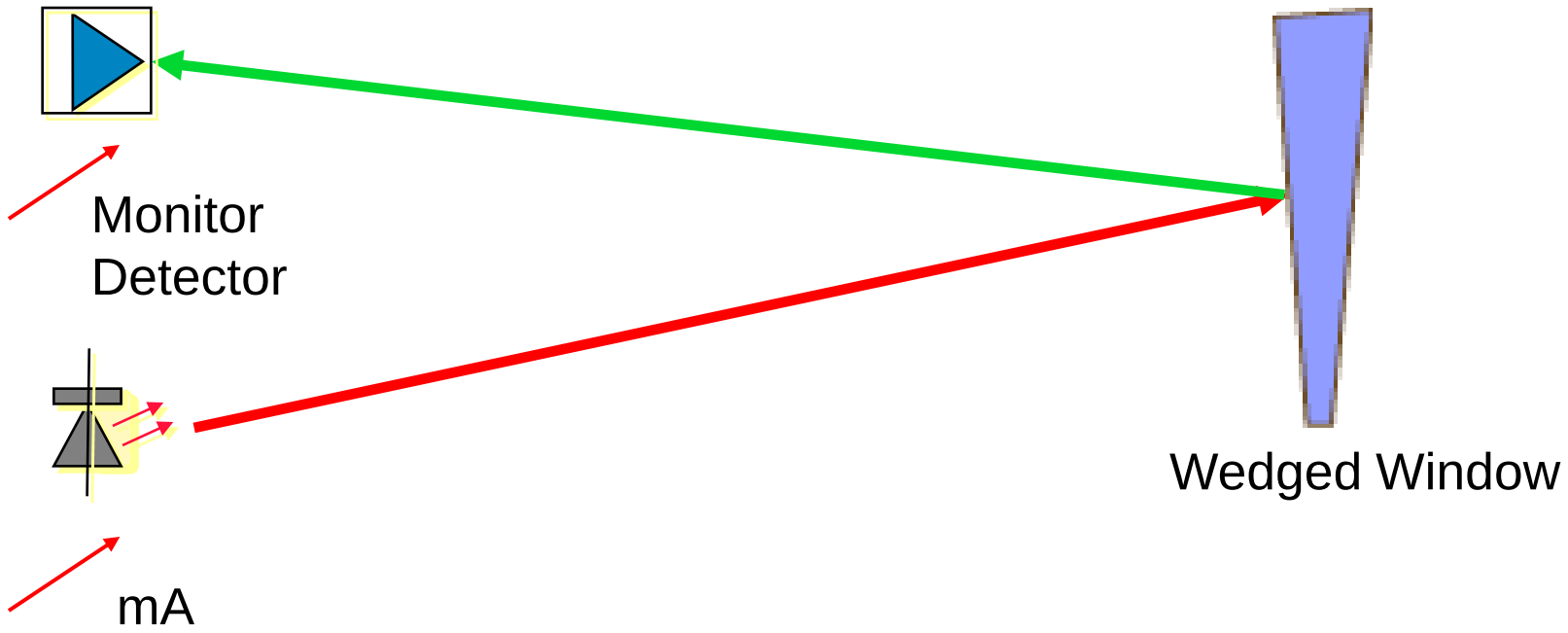
The gas molecules absorb the light at a specific wavelength.

The “scan”, a repeatedly applied ramp of current (sawtooth) provides a continuous measurement of the spectrum of the gas.



TDL Monitoring Technique

Monitor channel

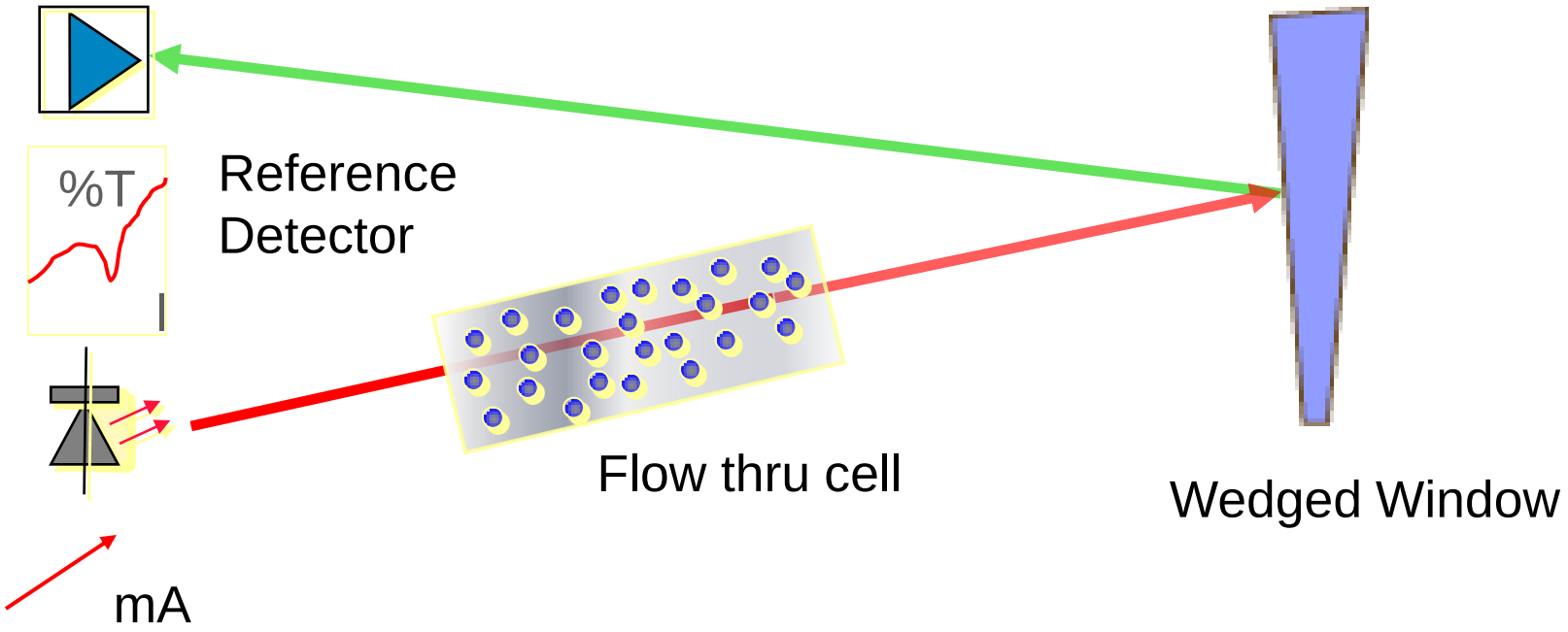


The light sent out by the laser diode is reflected by the wedged window directly onto the monitor detector, recording the light intensity „I^0“.

The measurement signal is normalized by the shape of the monitor signal to get a straight baseline in parallel to the X-axis.

TDL Monitoring Technique

Reference Channel



The gas-filled cell of the reference channel provides a spectrum of the gas to be measured. This is used to determine the position of the absorption line and to adjust the operating point of the laser accordingly, thus eliminating drift of laser properties.

TDL Monitoring Technique

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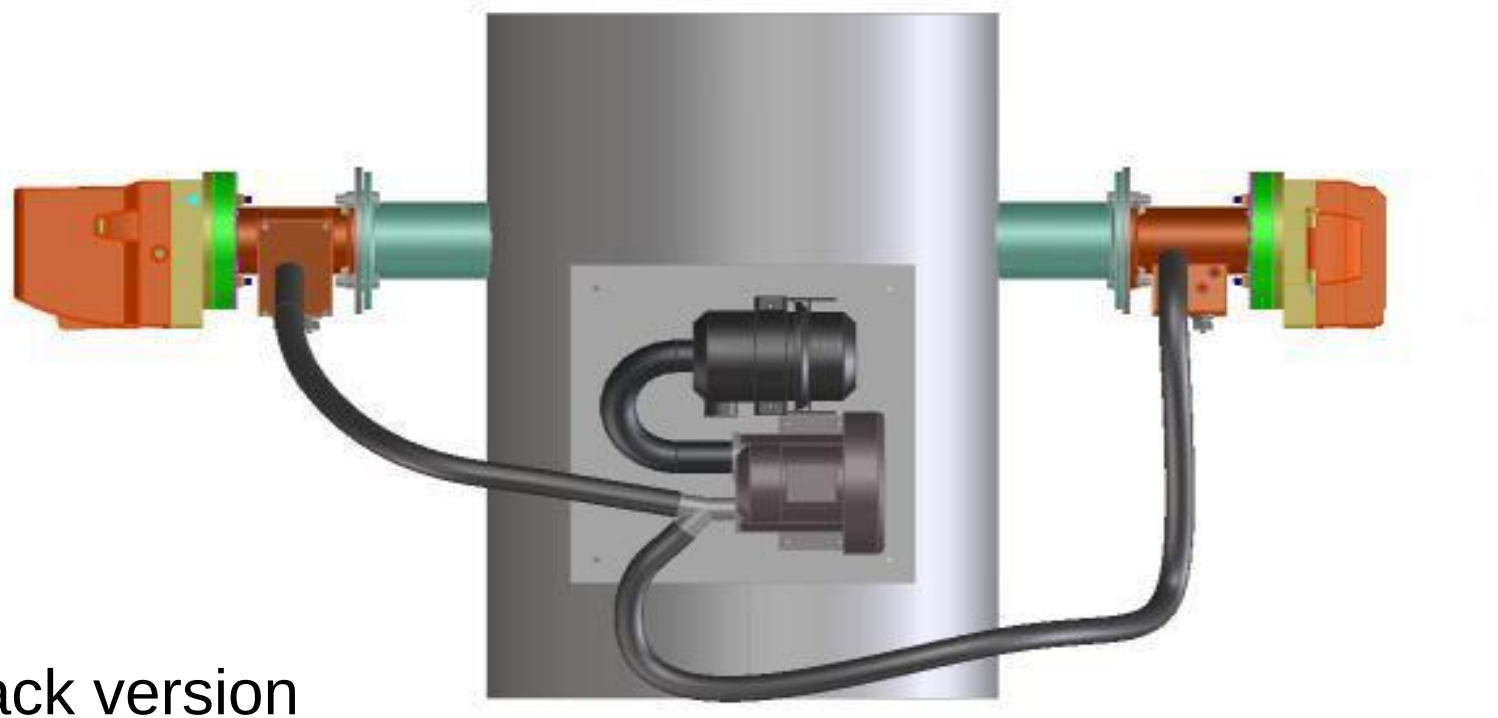
TDLS Cross Stack Versions – Min Range: 0-10ppm



Cross stack version

: Daily validation via gas filled cell

: CGA requires independent test device

TDL Monitoring Technique

TDLS Probe Versions – Min Range: 0-10ppm

Filtered Probe

: Calibration Gas testing at probe

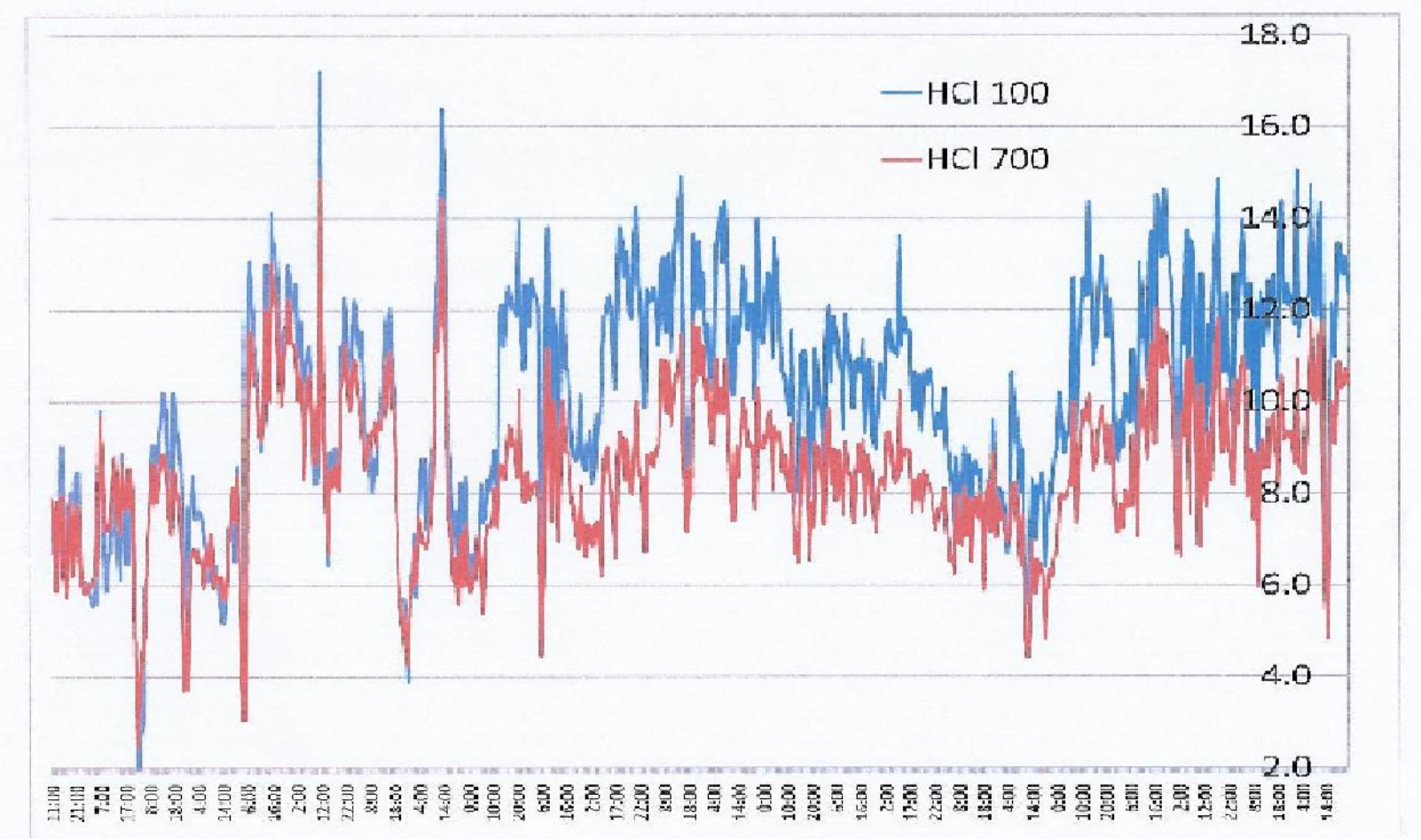
: Low process temperatures can cause reaction or loss of HCl on filter face

Open Path Probe

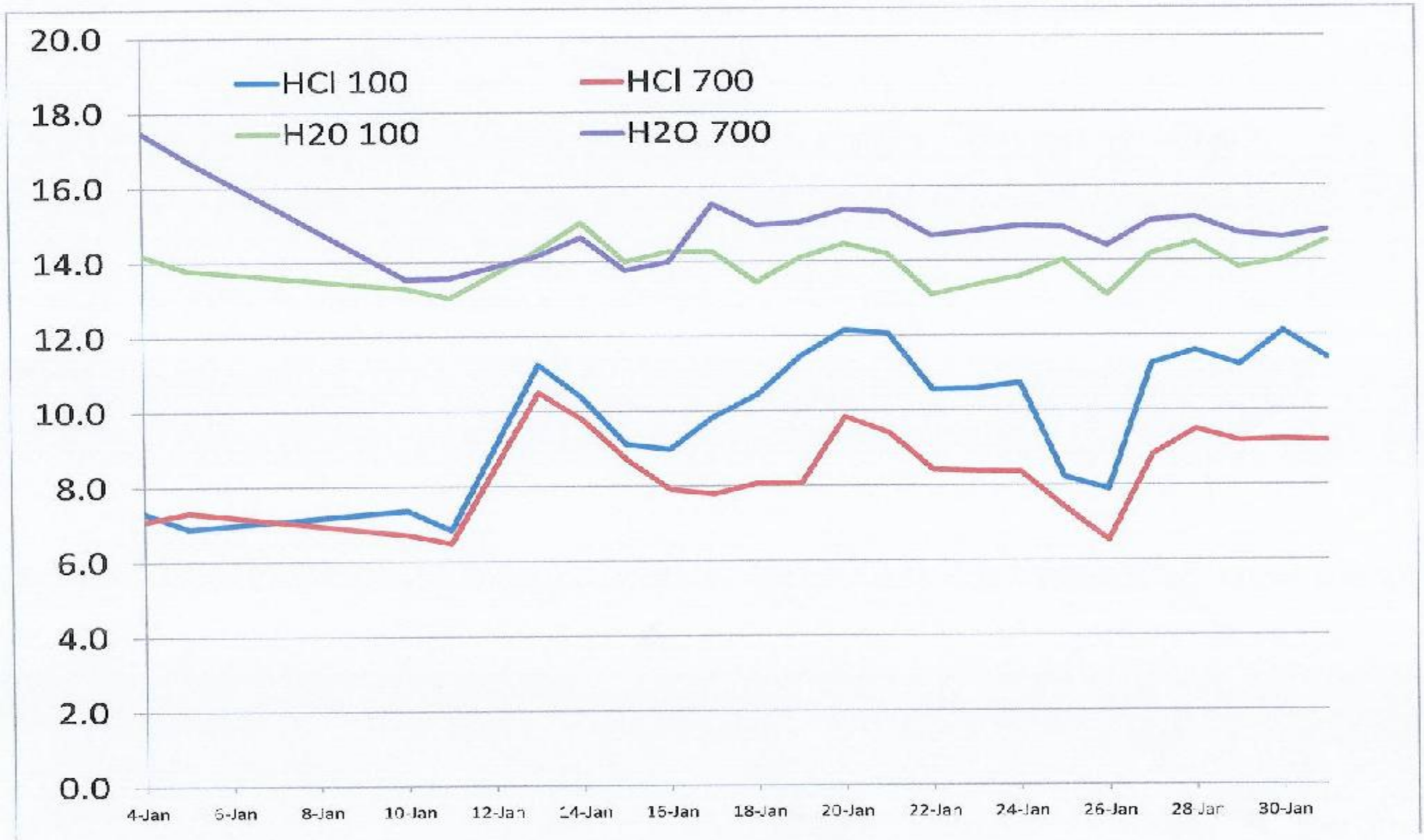
: Gas testing at probe not possible – independent test device required for CGA

: No issue with HCl loss on filter

HCL Monitor Data: MCS100HW vs. GM700



HCL Monitor Data: MCS100HW vs. GM700



TDL Monitoring Technique

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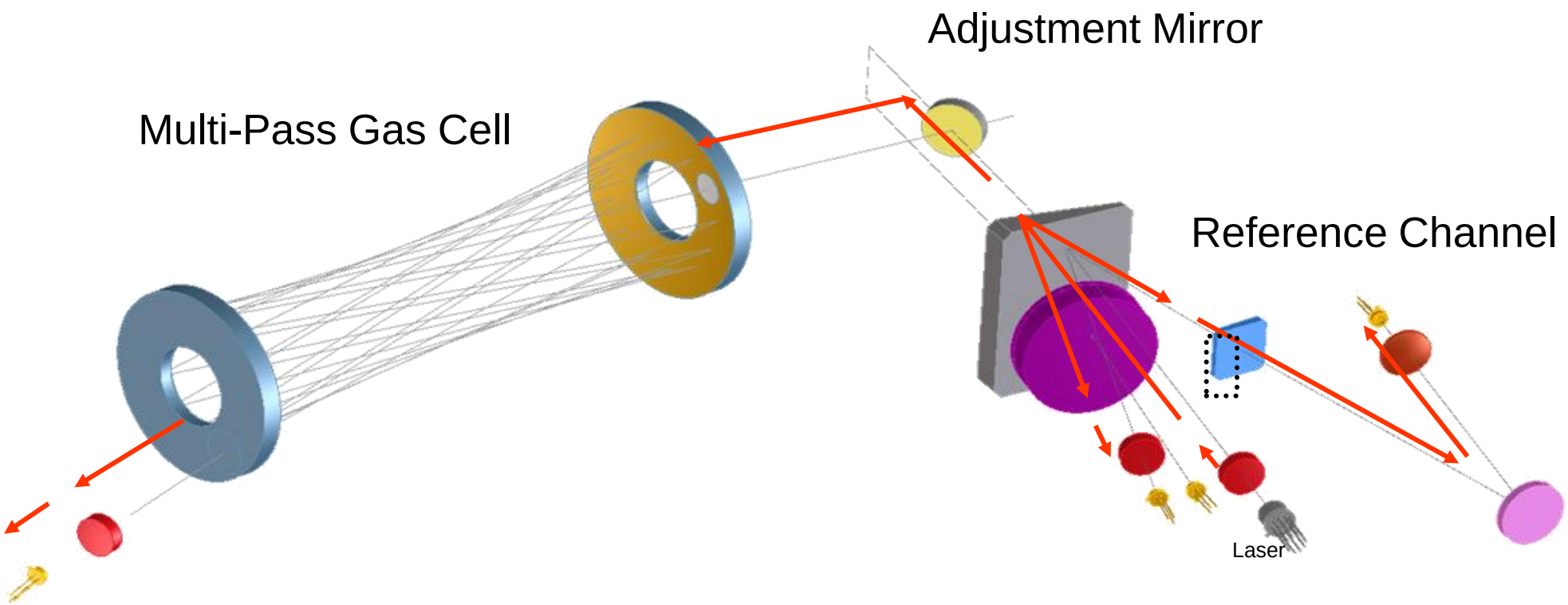
- A complete TDLS system in one housing
- Minimum Range: 0-5 ppm HCl
- Extractive „hot-wet“ measurement
- Heated, multi-pass sample cell
- 19” rack mounted analyzer

GME700

TDL Monitoring Technique



GM700 Measuring Schematic

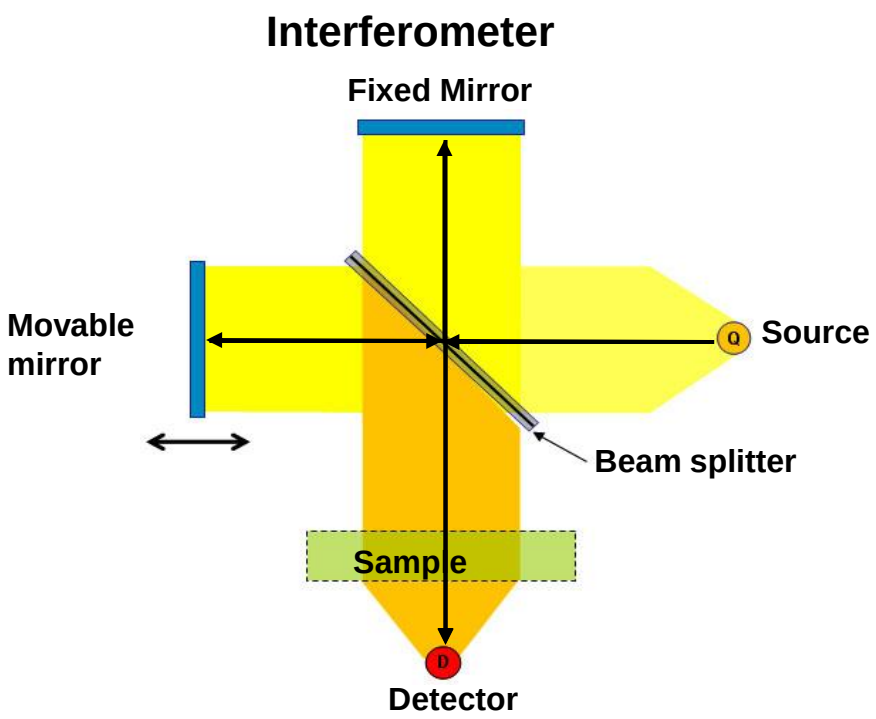
FTIR Monitoring Technique

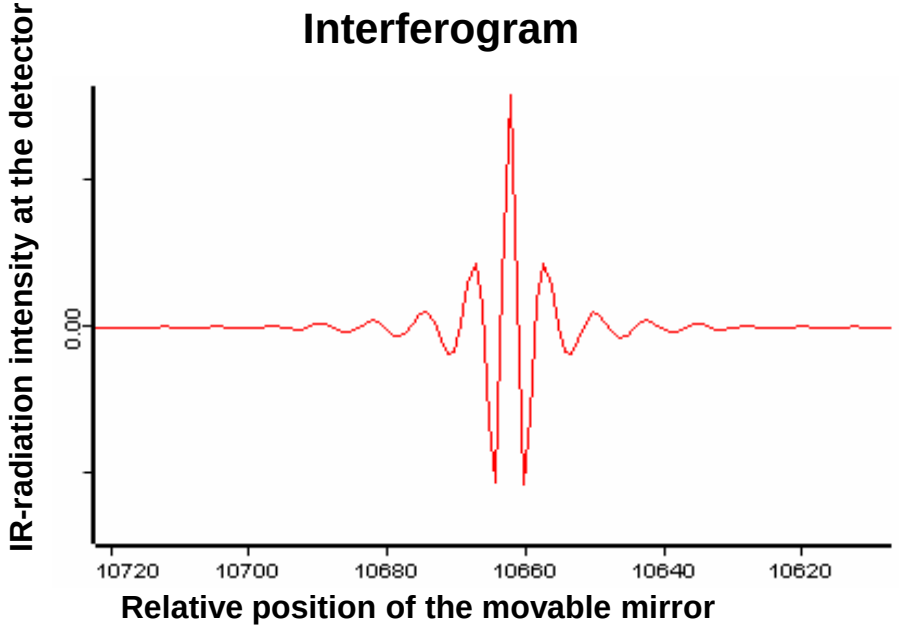
- Fourier Transform IR Technique utilizes a moving mirror and an interferometer to generate an “interferogram” of the sample absorption spectrum.
- Performing a mathematical Fourier transform on the “interferogram” generates an absorption spectrum of the entire used spectral range.
- FTIR can generate multi-component measurement results, including HCl.
- Hot wet sample system
- Internal gas calibration cell optional
- Typical minimum range of HCl: 0-10ppm

FTIR Monitoring Technique

- The Interferometer splits the light beam emitted by an IR source into
  - a fixed part
  - and a part that is periodically phase-delayed (moving mirror)

- When super-imposing one partial beam on the other, an interferogram is formed which is recorded by the detector.

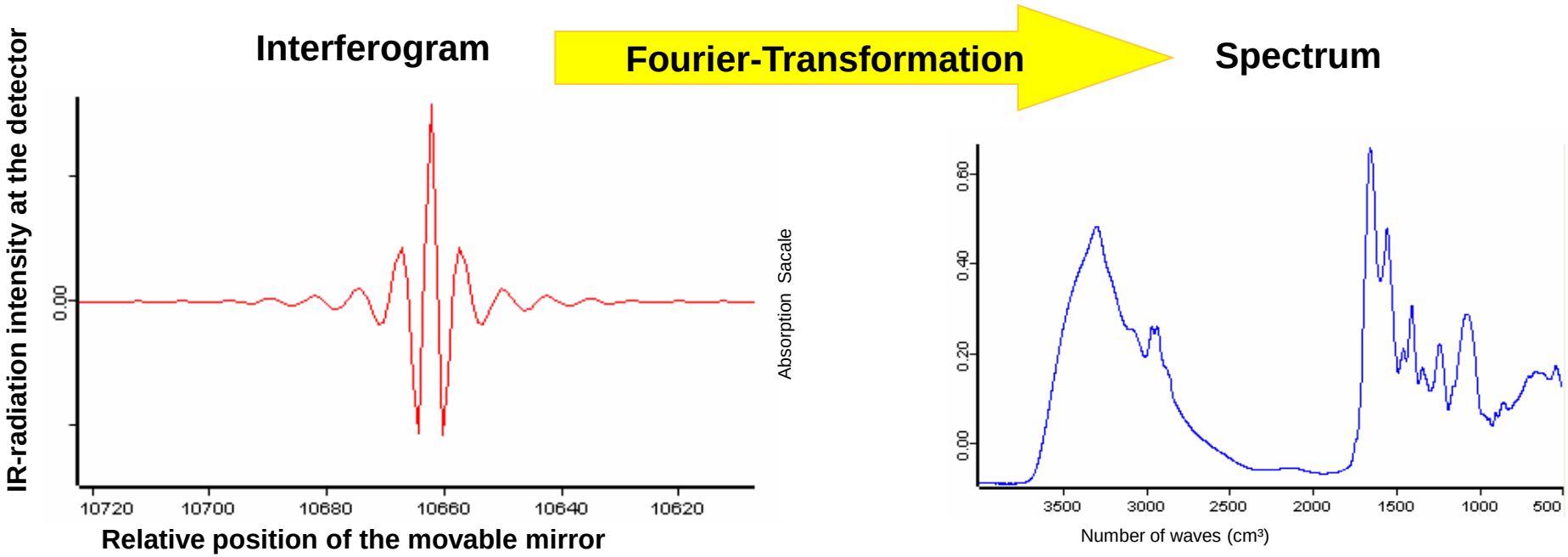




FTIR Monitoring Technique

: The interferogram measured is specific for the infrared spectrum.

- It contains the entire information of all IR-absorbing components.
- By means of Fourier-Transformation the corresponding spectrum can be calculated.
- This spectrum is the basis to calculate the sample gas concentrations by means of a chemometric model with comparison to library spectra.



Summary

- There are several well known and documented measurement techniques for monitoring of HCl
- Minimum range and detection limits meet current requirements
- NDIR and FTIR offer multi-component options
- TDLS offers single component option
- Sample handling is key
  - Keep Sample Hot and Move Sample Fast
- Calibration is the difficult due to Absorption and Desorption
  - Wet Calibration and proper ‘technique’ is critical

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Thank you for your attention.