Project Overview

Laser Spectroscopy Group

http://laser-spectroscopy.ucc.ie

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Project 1 & 2

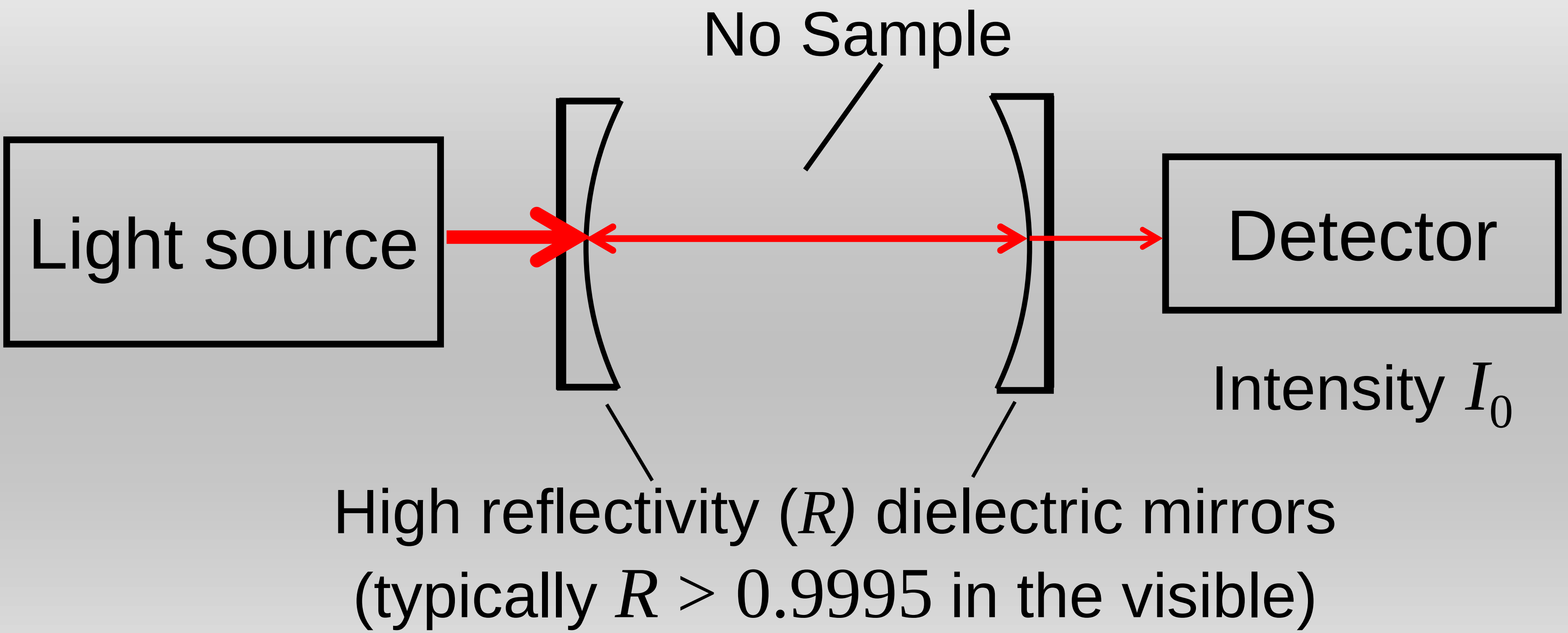
Incoherent Broadband Cavity Enhanced Absorption Spectroscopy

(1) A compact instrument for NO_2 detection
(2) Atmospheric simulation experiments

Desirable features of a spectroscopic absorption experiment?

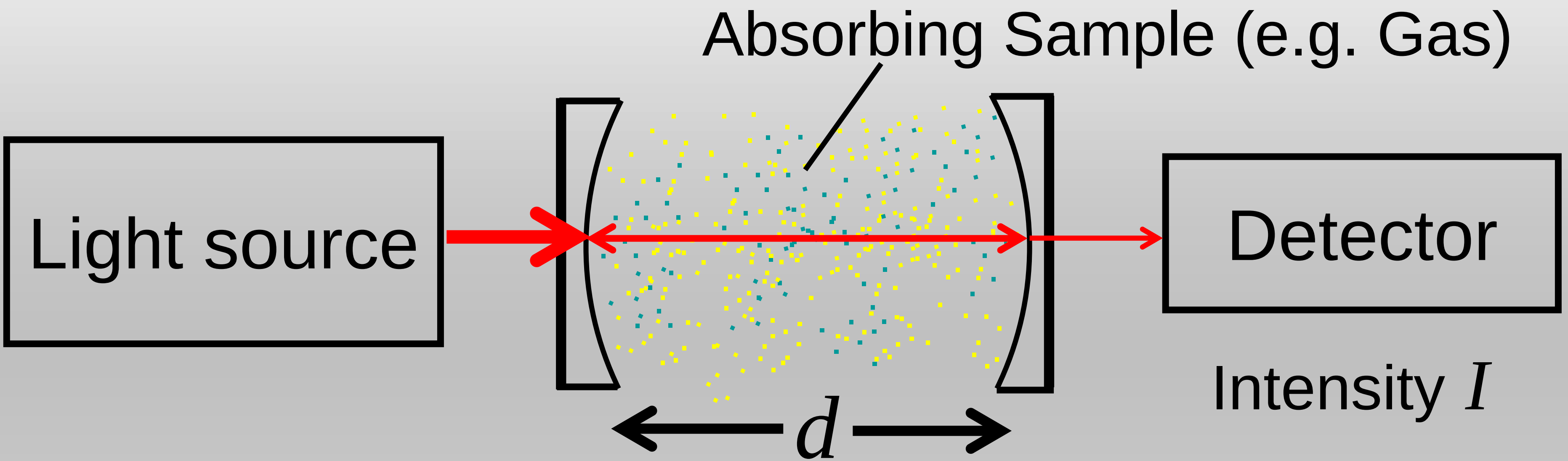
- **Sensitivity** long (eff.) absorption path length
- **Selectivity** unambiguous species identification
- **Speed** high time resolution
- **Quantitative and Direct Methodology**
- **Simplicity** / **Robustness** / **Reliability**
- **Versatility**

Cavity-enhanced absorption spectroscopy



Depending on the mirror reflectivity several kilometer path lengths can be achieved !

Cavity-enhanced absorption spectroscopy



Absorption coefficient α:

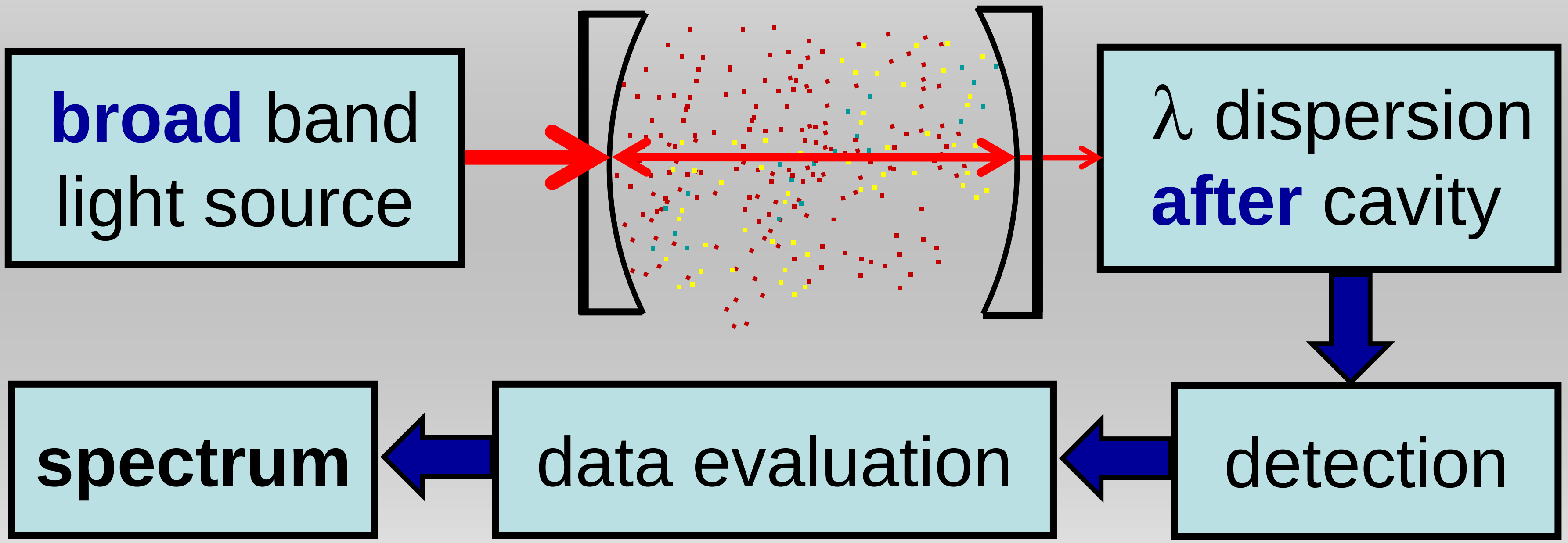
$$\alpha(\lambda) \approx \frac{1}{d}\left(\frac{I_0(\lambda)}{I(\lambda)} - 1\right)[1 - R(\lambda)]$$

Broadband Cavity-Enhanced Methods

Measurement principle:

(A) Spectrally **broad** light coupled into cavity

(B) Dispersion of wavelength **after** the cavity

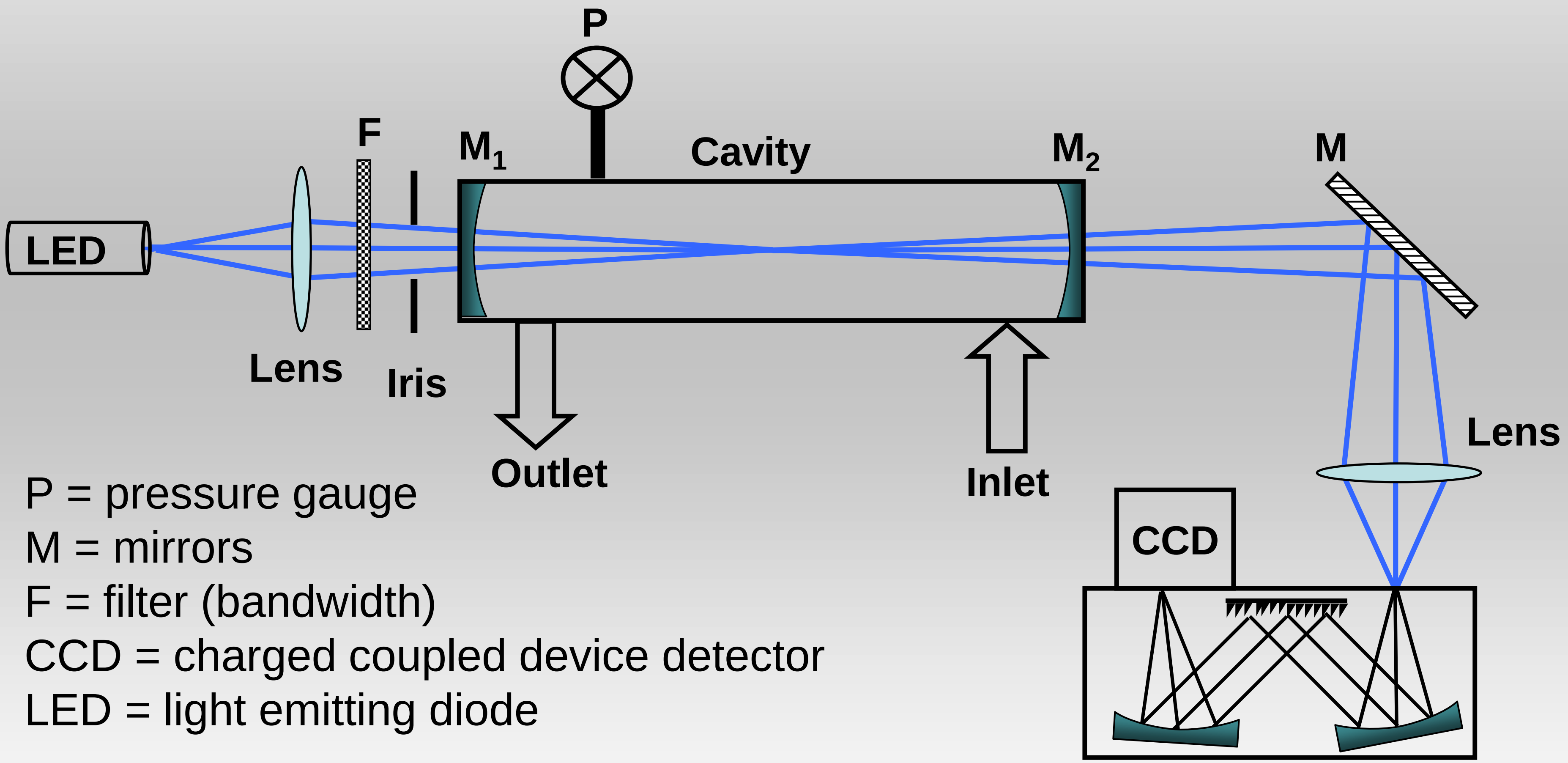


Multiplexing advantage:

(A) No scanning of wavelength required (in principle)

(B) High time resolution for wide spectral ranges

(1) A compact instrument for NO_2 detection

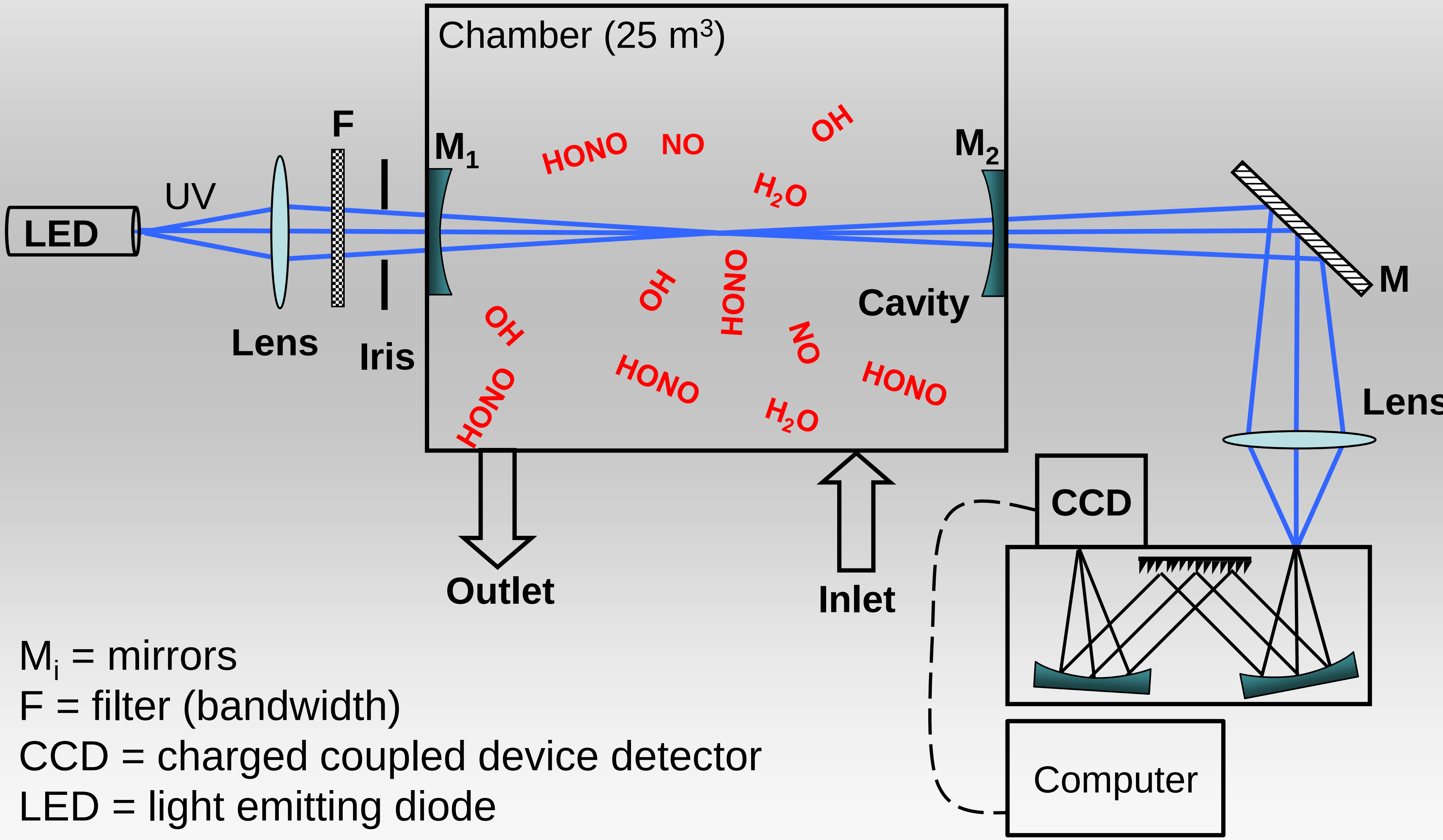


P = pressure gauge
M = mirrors
F = filter (bandwidth)
CCD = charged coupled device detector
LED = light emitting diode

Objectives / Activities (1)

- Characterization of blue LED.
  (spectrum, brightness, power, stability, divergence…)
- Setting up of IBBCEAS apparatus.
  (detection system – CCD, optical cavity, filter constraints)
- Proof-of-principle experiments. (characterization of experimental parameters: signal-to-noise ratio, detection limit, Allan variance…)
- Mirror reflectivity calibration.
- Setting up gas system.
  (a) close gas cell test measurements with NO_2
  (b) open path test measurements in ambient air

(2) Atmospheric simulation experiments



M_i = mirrors
F = filter (bandwidth)
CCD = charged coupled device detector
LED = light emitting diode

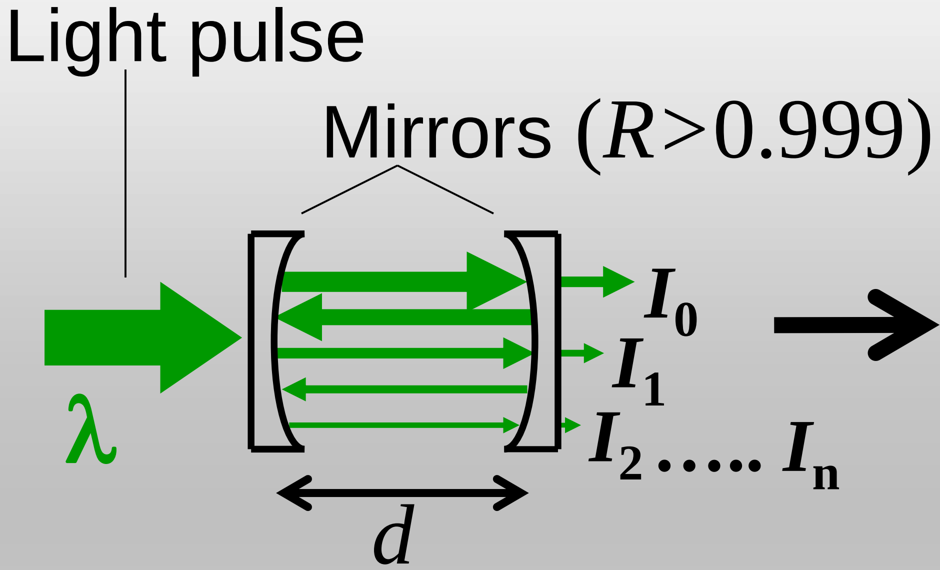
Objectives / Activities (2)

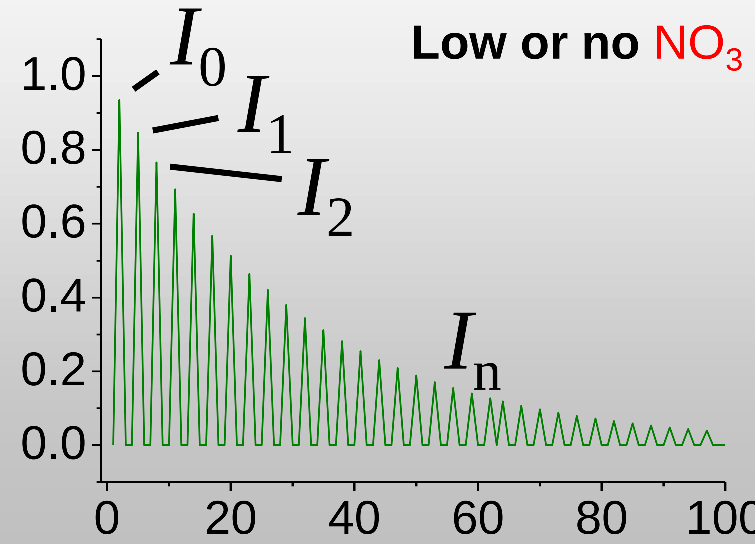
- Characterization of UV LED.
(spectrum, brightness, power, stability, divergence…)
- Setting up of IBBCEAS apparatus, implementation on atmospheric simulation chamber
(detection system – CCD, optical cavity, filter constraints)
- Proof-of-principle experiments. (characterization of experimental parameters: signal-to-noise ratio, detection limit, Allan variance…)
- Mirror reflectivity calibration.
- Measurement and discussion of:
(a) open path HONO spectra
(b) open path NO_2 Spectra and comparison with commercial chemiluminescence detector

Project 3

Trace gas absorption measured by cavity ring-down spectroscopy

Principle of the cavity ring-down method

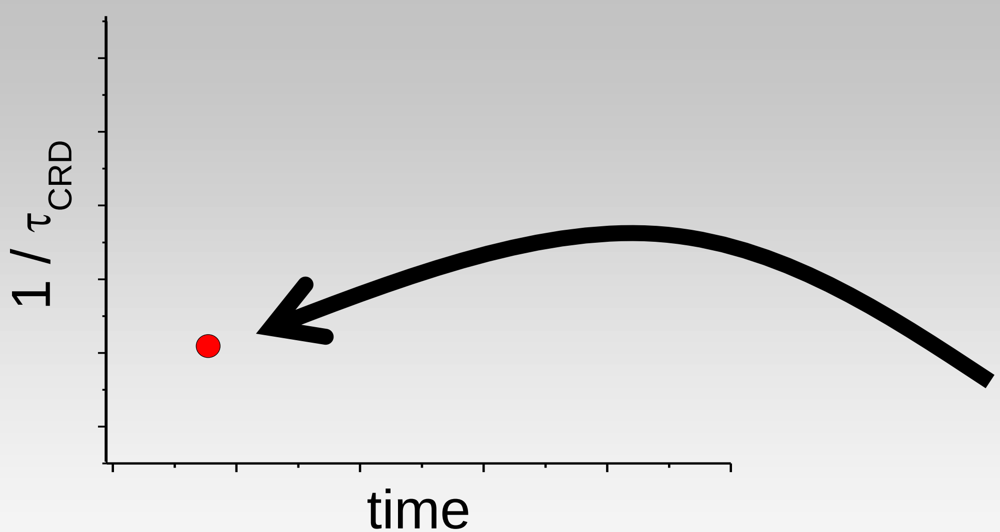




fit

$$I(t) = I_0 \exp\left(-\frac{t}{\tau_{crd}}\right)$$

$$\tau_{crd}^{-1} = \frac{(1-R)\,c}{d} + c\sigma n_{NO_3}$$



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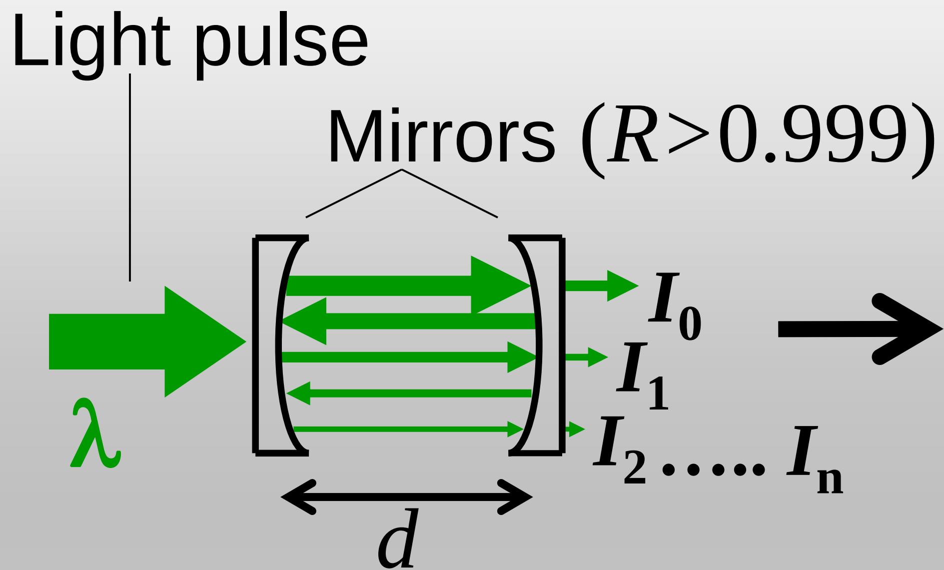

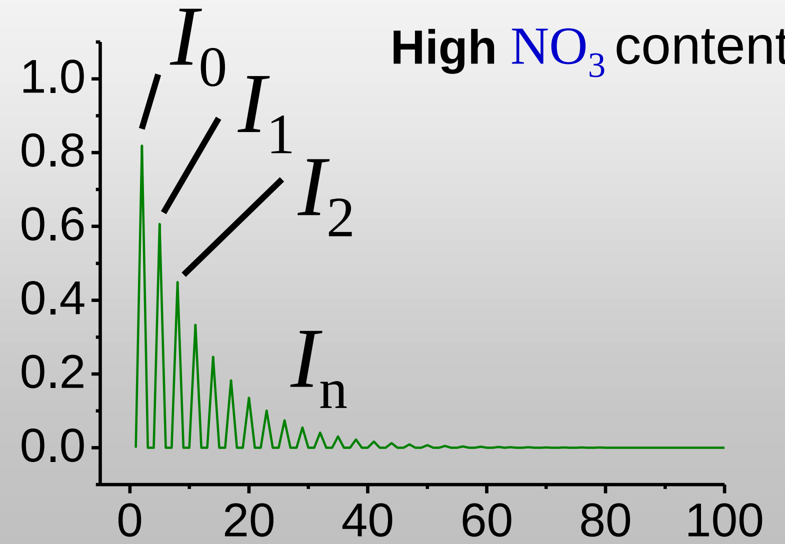

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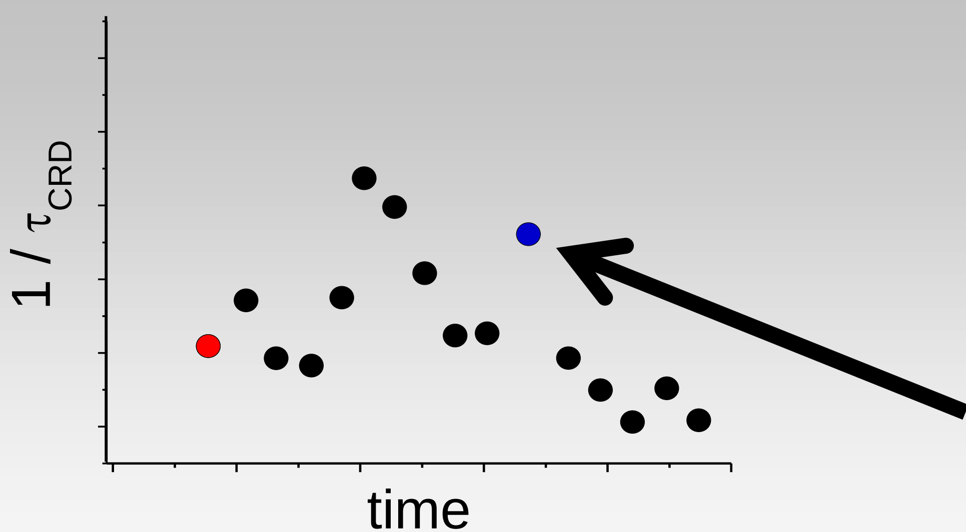
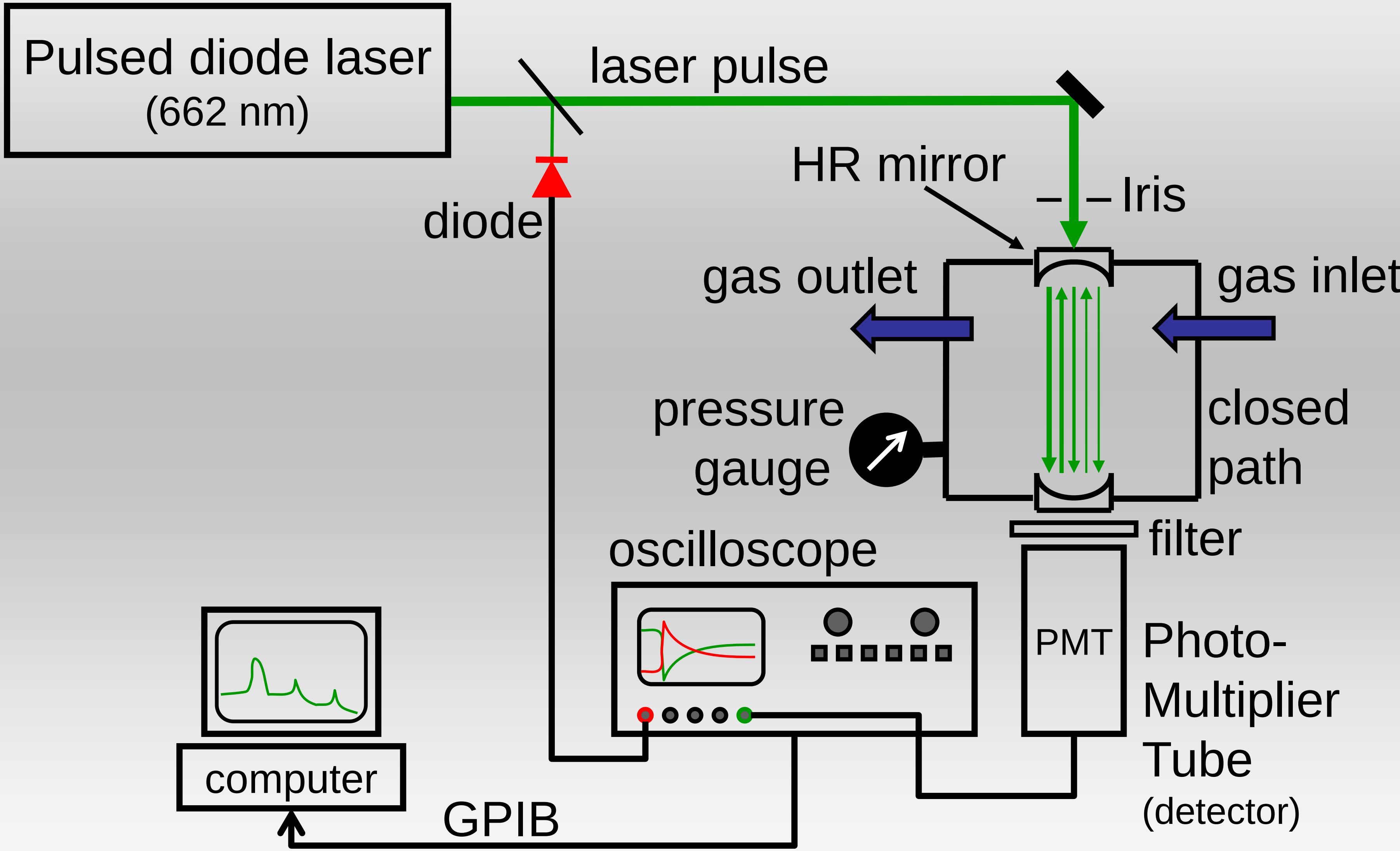


Cavity Ring-Down Experiment



Objectives / Activities (3)

- Setup a vacuum tight, pressure controlled, *closed-path* cavity.
- Setup software for measurement and data analysis.

- Measure ring-down times in the empty cavity to characterize the optical losses (e.g. as a function of pressure).

- Detect H_2O absorption in the cavity as a function of time (optimize integration time).

- Synthesize NO_3 (=NO_2 + O_3) in the cavity and detect the nitrate radical concentrations as a function of time (optimize integration time).