

## IN APPLICATION

# Laser Imaging for Soot Measurements

## FlameMaster LII imaging system

### Introduction

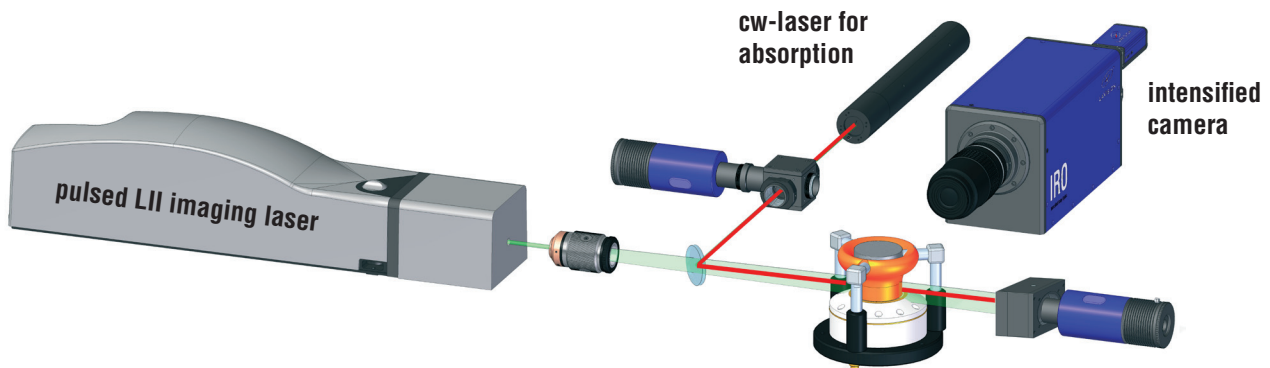
Particulates are considered the most hazardous form of air pollution. Therefore, the development of combustion technologies has long been focused on the reduction of particulate emissions. Laser-Induced Incandescence (LII) is a key technique to study soot generation by measuring particulates in-situ as soot volume concentrations and particle diameter distributions. Instantaneous concentration maps are recorded using fast shutter cameras with high spatial and temporal resolution. LII is orders of magnitude more sensitive than standard gravimetric sampling techniques allowing e. g. the detection of ultra low soot concentrations still present in modern combustion devices.

### Laser-Induced Incandescence (LII) imaging

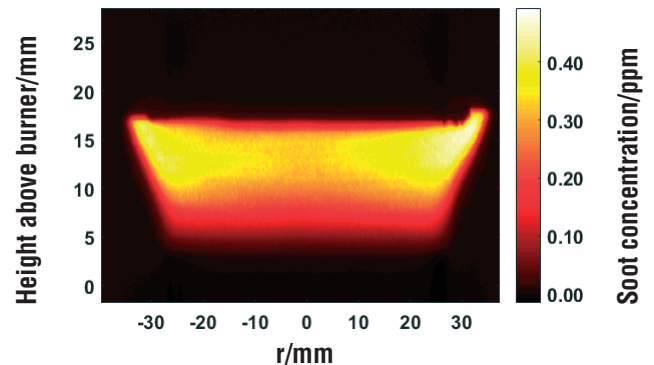
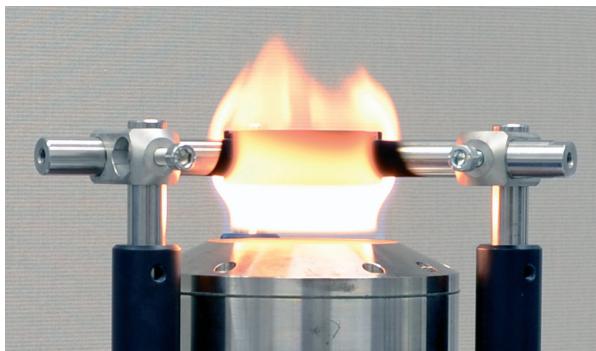
LII measures the blackbody emission (incandescence) of primary soot particles heated by a pulsed laser light sheet. A fast shutter camera is used for the time-gated detection of the spectrally filtered LII signal.

This interference-free LII signal is directly proportional to the soot volume concentration with detection limits in the ppt-range. Time-resolved LII measurements are also used to measure the size of primary soot particles.

For quantitative soot concentration measurements the LII signal has to be calibrated using a calibration burner with known soot concentrations or by means of a simultaneous absorption measurement.



*Experimental setup for quantitative 2D LII measurements with simultaneous in-situ absorption for LII signal calibration*



*Premixed ethylene/air flame of the calibration burner (left) and its measured 2D soot concentration field (right)*

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## Laser Imaging for Soot Measurements

### FlameMaster LII imaging system

#### FlameMaster LII imaging system

LaVision's multifunctional **FlameMaster** laser imaging system supports quantitative 2D soot measurements using a fast shutter intensified camera for LII signal imaging excited by pulsed laser light sheets. Besides time-gating of the camera to reject flame luminosity a spectral filter is used in front of the camera lens to isolate the LII signal from other unwanted laser-excited emissions like, e. g. fluorescence from polycyclic aromatic hydrocarbons, or wall reflections of the laser light. A special **DaVis** software module guides the user through the LII imaging process.

#### System Features

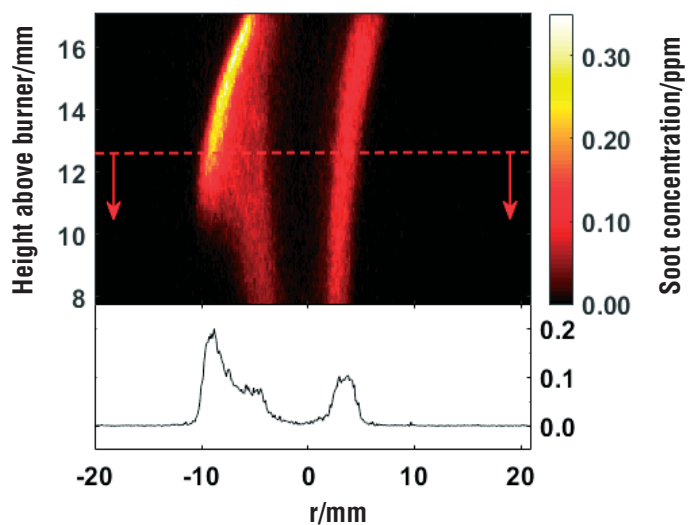
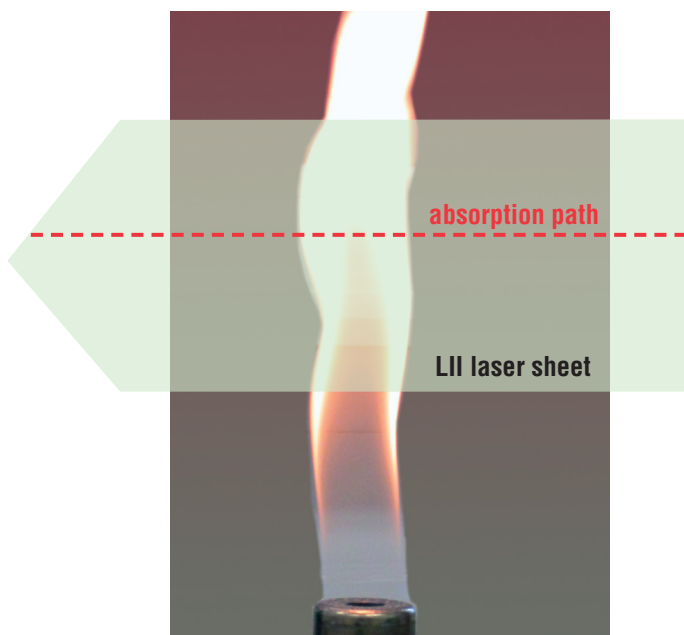
- ▶ soot volume concentrations obtained from calibrated LII images
- ▶ 2D measurement from single-laser shots with high spatial and temporal resolution
- ▶ calibration burner with known soot concentrations
- ▶ alternative calibration method using in-situ calibration via cw-laser extinction device

#### In-situ calibrated LII signals

In order to derive quantitative soot volume fraction concentrations without using a calibration burner the LII signal is calibrated by means of a simultaneous absorption measurement. For that the integrated LII signal along the absorption path is directly related to the measured absorption and determines the calibration factor that converts LII signals into soot volume fraction values.

#### Applications

- ▶ in-situ visualization of particulate matter
- ▶ time-resolved visualization of soot generation
- ▶ optimization of turbulent combustion processes
- ▶ environmental applications



*Non-premixed propane Bunsen flame (left) with an instantaneous soot concentration field (right) calibrated with the in-situ absorption method*

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