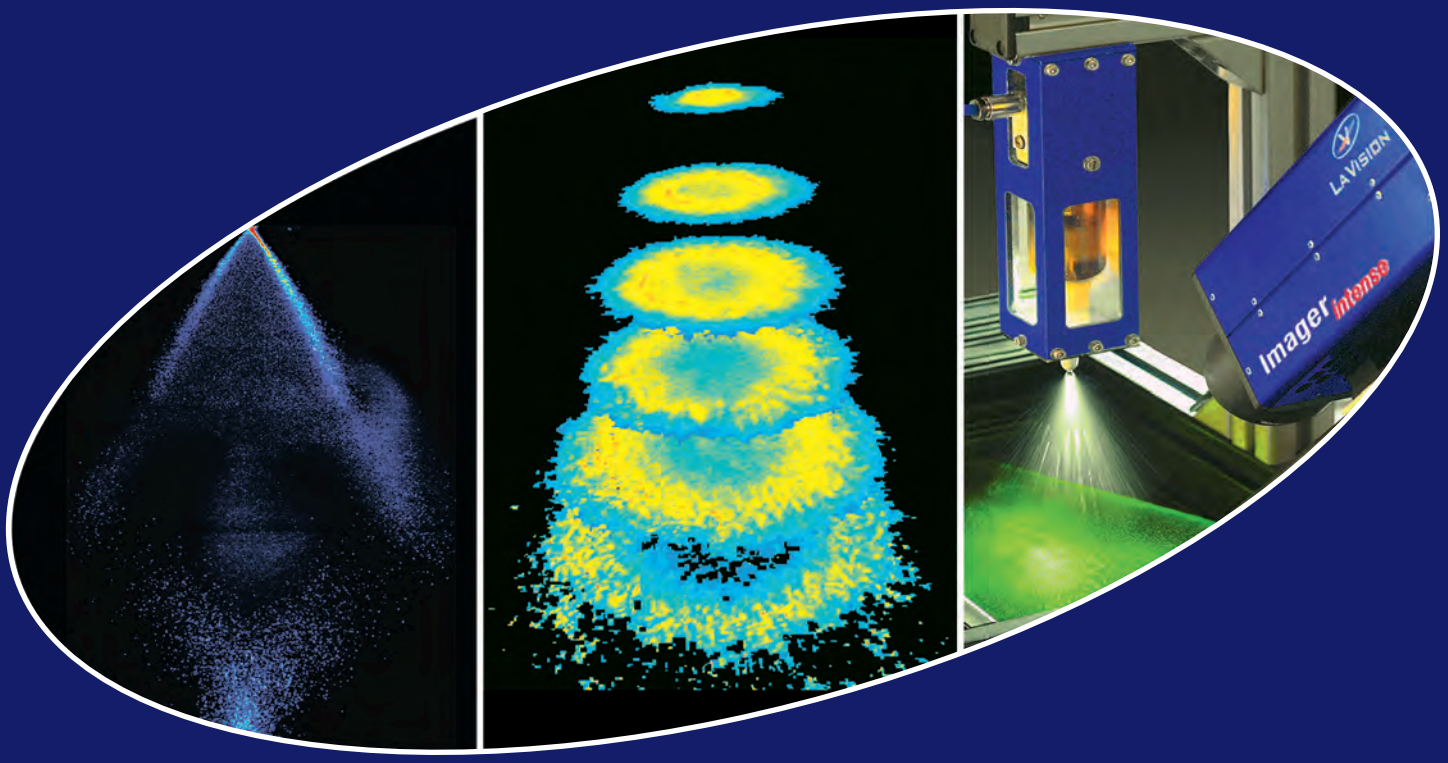


SprayMaster

Advanced Spray Analysis
based on
Laser Light Sheet Imaging

LAVISION

FOCUS ON IMAGING

SprayMaster
Vision for Sprays

SprayMaster is a complete family of optical measurement systems for non-intrusive spray analysis.

Easy and Fast to Operate

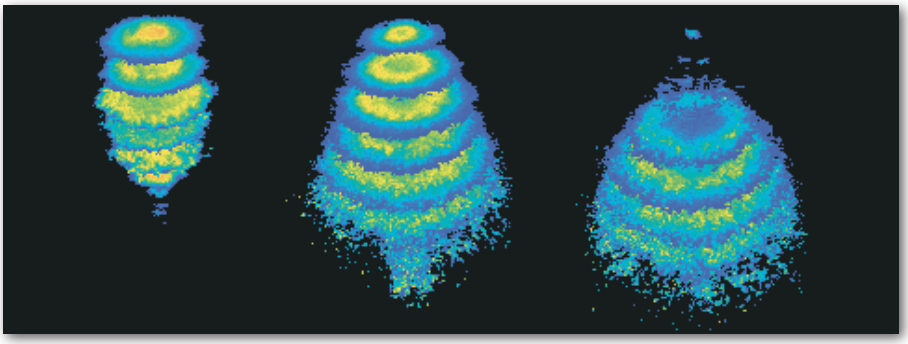
SprayMaster systems are easy to operate, fast and efficient measurement tools suitable forR&D as well as quality control applications.

State-of-the-Art Measurement Technique

The innovative and state-of-the-art measurement techniques applied in the **SprayMaster** systems provide a new insight into spray performance and permit cost effective and efficient development of nozzles and injectors.

Integrated Turn-key Spray Imaging Systems

LaVision is committed to its customers. We work in close cooperation with our customers to solve their specific needs with innovative solutions. Integrated turn-key spray imaging systems withunique capabilities are our specialty.



Temporal evolution of a pulsed spray: time sequence of the global spray mass distribution

SprayMaster
Applications

Combustion
- oil burners
- automotive sprays (diesel and gasoline)
- gas turbines

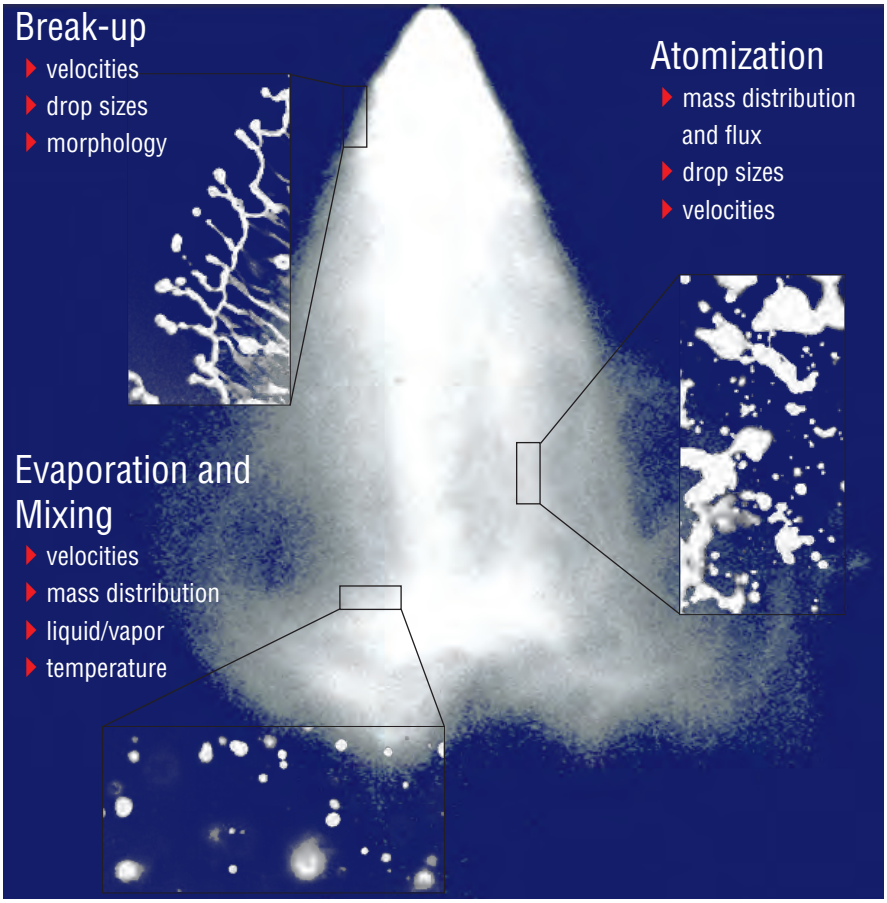
Coating and Additives
- painting
- insulation and encapsulation

Treatment
- humidification and misting
- washing and cleaning
- fire protection (sprinkler systems)
- agriculture

Production & Processing
- drying and cooling
- foam and dust control

SprayMaster
Processes & Quantities

The major task of a spraying application is the conversion of a liquid fluid into fine droplets having a designated size range and distribution. The processes involved are the break-up of the liquid structures and ligaments into droplets followed by further atomization into smaller droplets. Eventually the fluid may evaporate and mix with the surrounding gas.



The physical mechanisms in spray atomization are governed by the consolidating influence of the surface tension and liquid viscosity of the fluid and the opposing effect of aerodynamic external forces. Evaporation of the droplets occurs as a result of heat and mass exchange with the surrounding gas. As these processes take place in a millisecond time scale and in a millimeter spatial range, diagnostics for spraying applications require high spatial and temporal resolution without disturbing. This is achieved by using optical diagnostics based on laser imaging:

Laser Imaging as Versatile Tools

- instantaneous visualization of turbulent and transient flows
- comprehensible quantitative data
- non-intrusive and non-destructive
- excellent spatial and temporal resolution

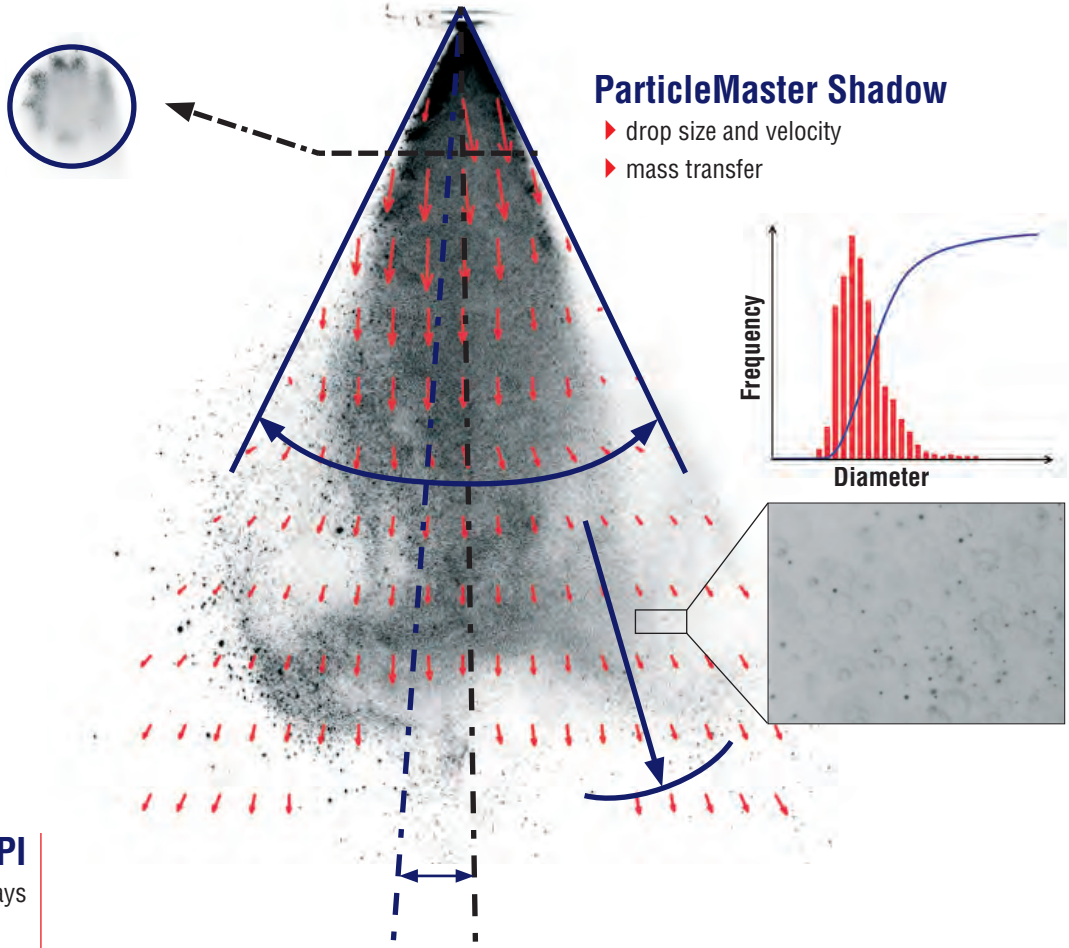
SprayMaster
Diagnostics Overview

SprayMaster inspex
- tip penetration
- cone angle
- patternation
- dispersion
- liquid mass

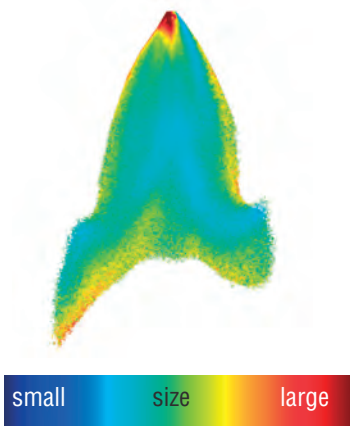
Laser Flow Tagging (LFT)
- liquid/gas phase velocity

FlowMaster
- flow field
- mass flux

ParticleMaster Shadow
- drop size and velocity
- mass transfer

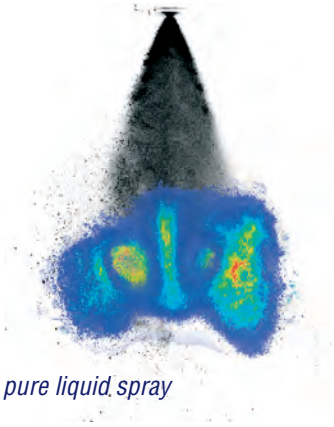


SprayMaster D32
- global droplet sizing

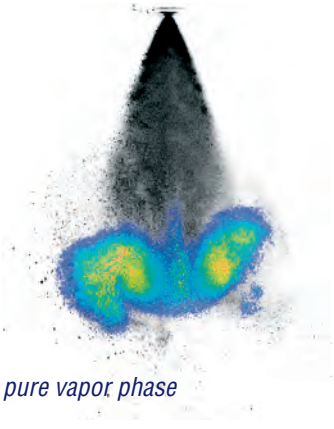


SprayMaster SLIPI
- advanced imaging in dense sprays

SprayMaster Exciplex
- liquid/vapor phases
- liquid temperature
- air entrainment



pure liquid spray



pure vapor phase

SprayMaster
System Family

The **SprayMaster** system family features a wide range of applications. It opens with the inspex systems based on fiber coupled backlights or sheet optics for determination of spray geometry and patternation. Upgrading to visible or UV lasers and advanced camera systems extends the range to measurement of droplet sizes or mass distribution maps.
The entire timing is controlled from the **SprayMaster** system also enabling automatic phase scans for pulsed spray applications. A customized Graphical User Interface (GUI) and remote control of a **SprayMaster** system are additional upgrades supporting the inline/online quality control capabilities.

SprayMaster models	based on	inspex flash + camera	visible laser + camera	UV laser + intensified camera
geometry, patternation	Mie	●	●	●
mass distribution liquid/vapor	LIF		● / ○	● / ●
global droplet sizing	LIF/Mie		●	●
phase separation liquid/vapor	LIEF		○	●
mass flux	LIF*PIV		○	○
enhancement in dense sprays reduction of multiple scattering	SLIPI		○	○

● standard feature ○ upgrade option

Mie Mie scattering is elastic scattering caused by surface interaction. The emitted wavelength is the same as the excitation wavelength. The signal strength is proportional to the total surface area of the particle or droplet.

LIF Laser Induced Fluorescence (LIF) is a two step process involving absorption of laser light and subsequent emission at a different wavelength. LIF is dependent on the volume of LIF active species, thus, its signal intensity scales with the droplet volume or mass concentration.

LIF / Mie The ratio of LIF signal (volume dependent) and Mie signal (proportional to surface area) in a spray is used for global droplet sizing yielding the Sauter Mean Diameter (SMD) or D_{32}, respectively.

LIEF Laser Induced Exciplex Fluorescence (LIEF) is a special tracer LIF technique for simultaneous visualization of two phase flows. Vapor and liquid phase can be spectrally separated using optical filters.

PIV Particle Image Velocimetry (PIV) is a technique for determining instantaneous flow fields and further characteristics in fluid mechanics.

LIF*PIV The combined detection of the liquid or gaseous mass (via LIF) and the out-of-plane flow field (via PIV) enables determination of mass flux perpendicular to the light sheet plane.

SLIPI Structured Laser Illumination Planar Imaging (SLIPI) is a technique where a spatially modulated laser sheet is utilized in combination with special image processing to reduce the effects of multiple scattering in dense sprays. SLIPI can be based on Mie scattering or LIF.

SprayMaster
System Components

LaVision offers complete system solutions for almost any spraying application. The systems meet the needs for sturdy OEM products and the demanding requirements of the scientific community for a powerful versatile diagnostic tool.

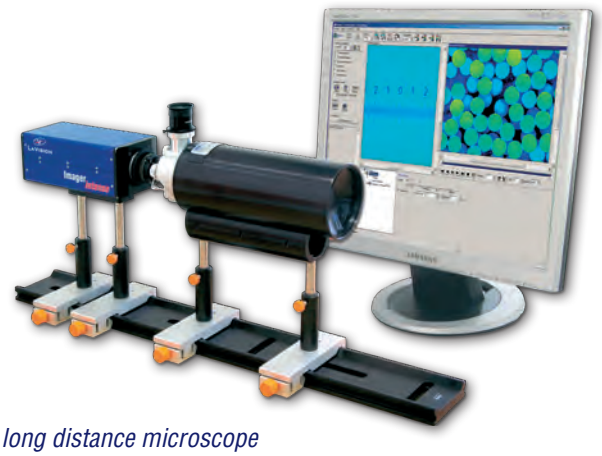
Each **SprayMaster** system comprises light sources, special optics and CCD or CMOS sensors which are easily adapted to the spraying chamber or other test rigs.

Illumination Optics
- sheet optics & collimator
- laser endoscope
- illumination probe
- backlight

Light Source
- high energy YAG laser (UV & visible)
- high speed YAG laser
- flashlamp
- LED

Beam Delivery
- laser guiding arm
- fiber optics
- liquid light guide

hybrid camera endoscope system



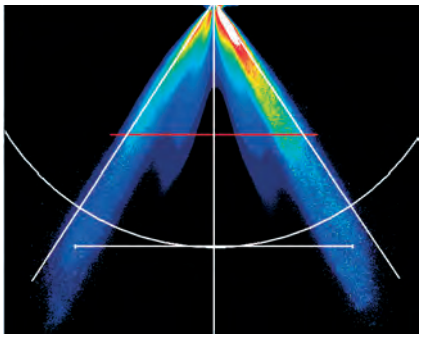
long distance microscope

Detection Optics
- standard and UV lens or endoscope
- long distance microscope
- hybrid camera endoscope for superior sensitivity

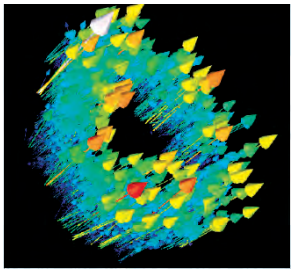
Options
- (multi-pulse) on-line laser energy monitor
- external laser shutter for more stable UV-operation
- traversing systems for scanning

SprayMaster Results

Mass Distribution/ Mass Flux



- combined measurement of radial mass distribution and stereo PIV yields mass flux

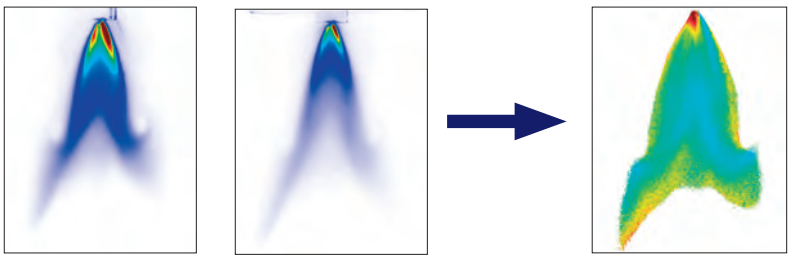


Geometry

- interactive parameter setup
- automatic identification of injector position
- individual evaluation of sprays from multi-hole nozzles

Global Droplet Sizing

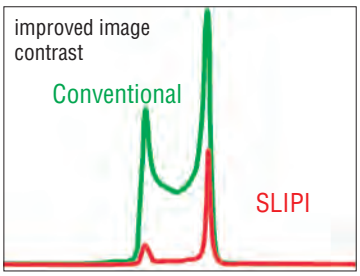
- simultaneously record LIF and Mie images
- determine Sauter Mean Diameter (SMD, D_{32}) from volume/surface area ratio

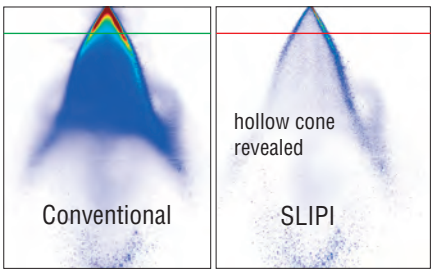


LIF = volume | Mie = surface | D_{32}

Novel Technique for Imaging in Dense Sprays

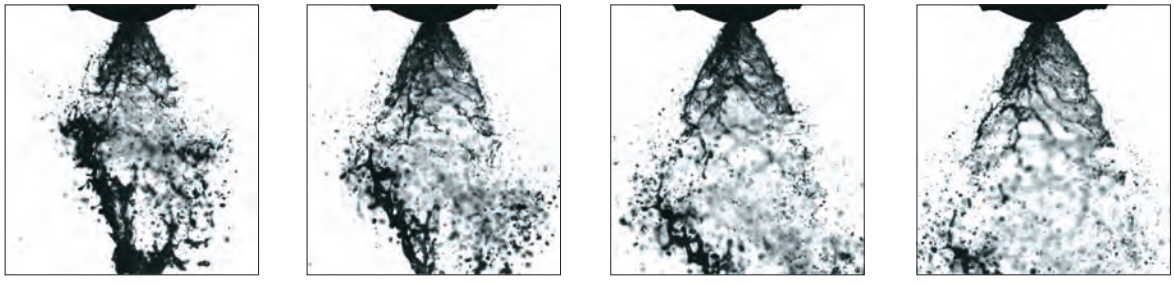
- intelligent reduction of multiple scattering by Structured Laser Illumination Planar Imaging (SLIPI)
- SLIPI reveals the inner structure of sprays which is usually hidden due to multiple scattering



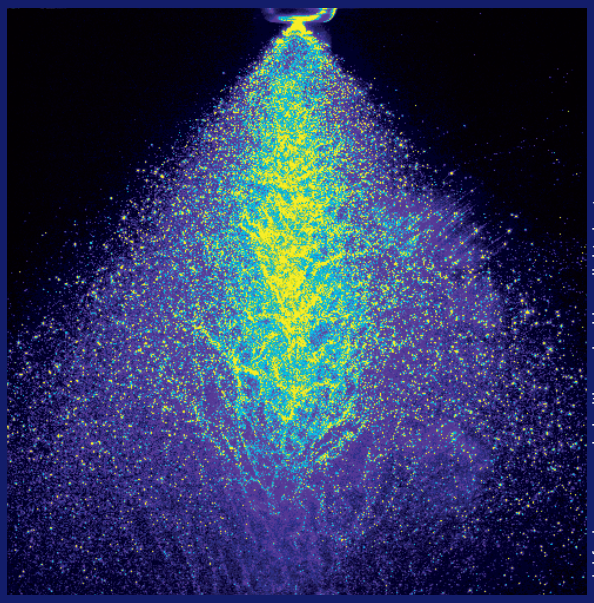


High-speed Imaging

- visualization of single transient phenomena
- recording rate of several kHz



Vision for Sprays



axial fuel map recorded with a pulsed laser light sheet

SprayMaster

laser based imaging for smarter spray systems

- geometry, patternation
- mass distribution liquid/vapor
- liquid temperature
- global droplet sizing
- reduction of multiple scattering
- phase separation
- mass flux

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