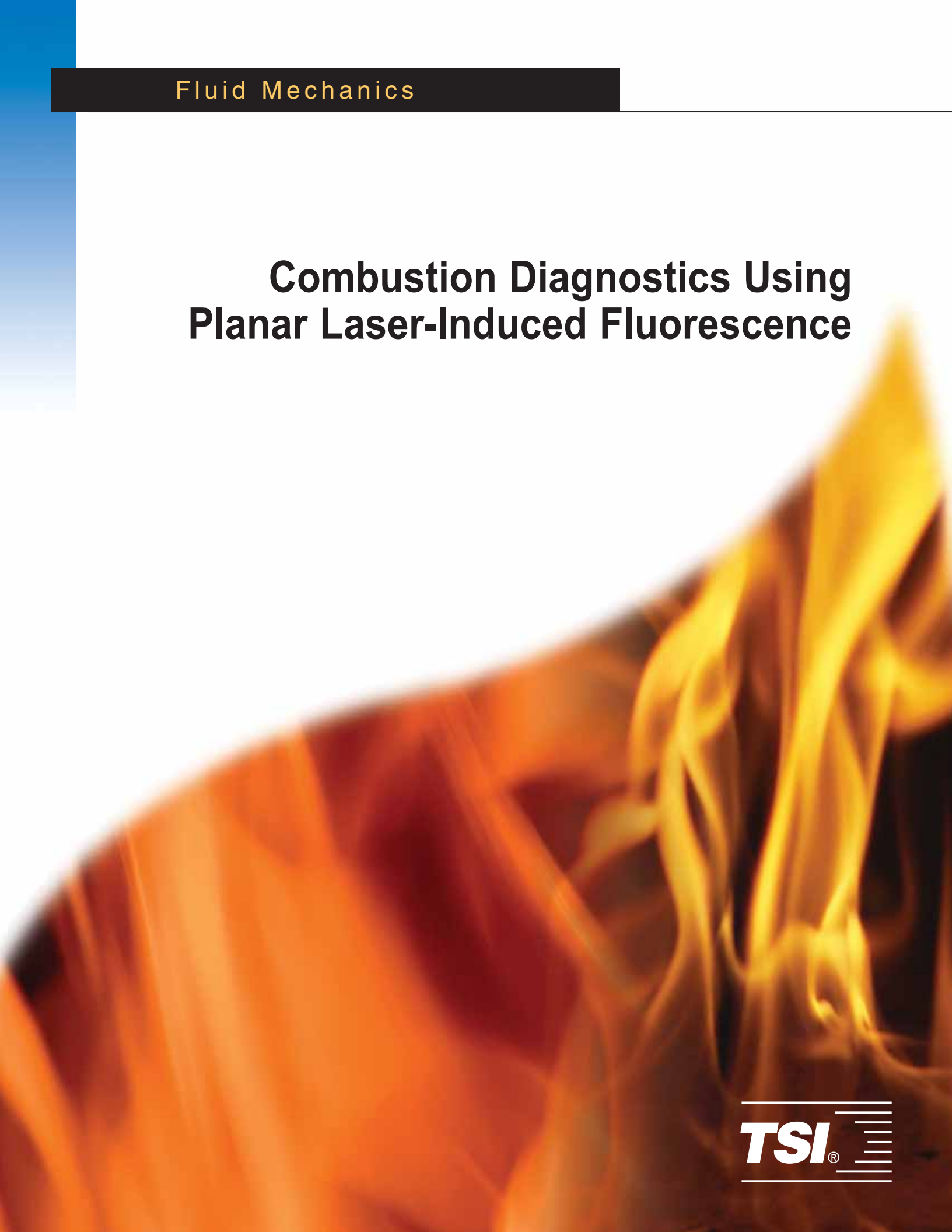
Fluid Mechanics

Combustion Diagnostics Using Planar Laser-Induced Fluorescence



TSI®

System Features

- Complete hardware control
- Complete arsenal of image processing, arithmetic, analysis, and display tools
- Linear and Curve-Fit Calibration Algorithms
- Correction Algorithms for:
  - Background Removal
  - Pulse-to-Pulse Energy Fluctuations
  - Spatial Variations in Light Sheet Intensity
  - Laser Attenuation
  - Variations in Individual Pixel Response
- Spatial Calibration algorithms for combining results from multiple cameras and/or measurement techniques

Planar Laser-Induced Fluorescence (PLIF) measurements in combustion environments are becoming increasingly common as a means to assess performance and efficiency of a broad range of combustion phenomena. From local fuel concentrations and consumption to flame front geometry, and from flame propagation to chemical species distributions, PLIF measurements provide invaluable insight into the details of combustion processes.

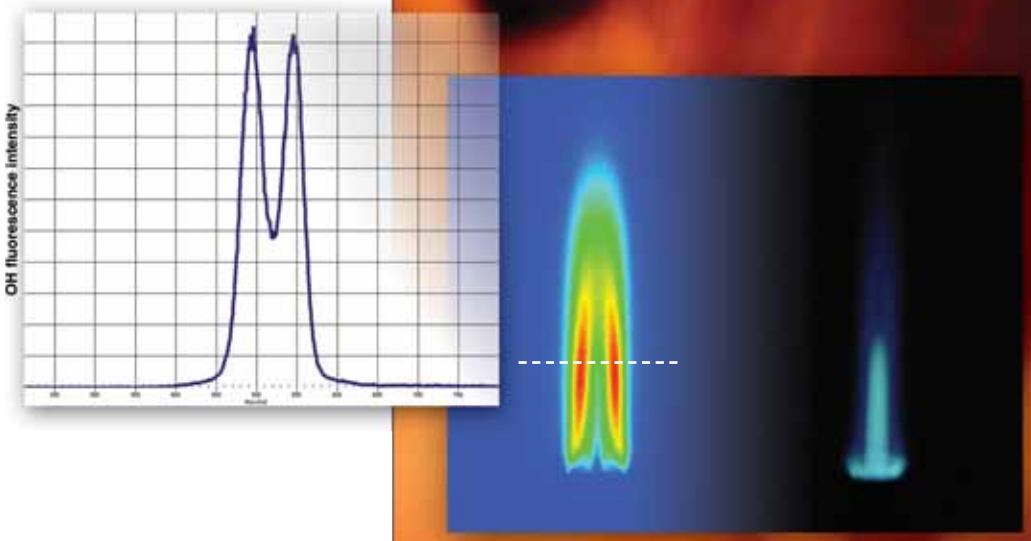
A single laser source illuminates the plane of interest and the advanced *INSIGHT 3G*™ software platform provides seamless, direct conversion of raw images to processed data. All hardware components are controlled directly through the *INSIGHT 3G* software, allowing for rapid setup and turnkey operation using stored hardware parameters.

The *INSIGHT 3G* software incorporates proprietary algorithms to correct for potential sources of measurement error such as spatial variations in light sheet intensity, pulse-to-pulse laser energy fluctuations, laser attenuation, variations in individual pixel response, and extraneous background signals. In addition, the *INSIGHT 3G* platform leverages the benefits of external software packages such as MatLab and TecPlot. Rather than relying upon risky modifications to an immense base of source code, which are not only difficult to implement, but also endanger overall system performance, the *INSIGHT 3G* software provides a direct interface to both MatLab and TecPlot for unlimited flexibility in implementing customized algorithms. MatLab is commonplace in most scientific facilities, and provides a powerful tool for implementing unique and specialized image processing algorithms in a well established, documented programming language. Using the direct link, users can define algorithms in the MatLab environment and execute them directly through the *INSIGHT 3G* software, with automatic controls for all data transfer. These external MatLab routines can even be incorporated into multi-step processing routines within *INSIGHT 3G*, and then executed with a single mouse click. A built in TecPlot toolbox provides a host of advanced display options for highlighting and examining all of the details of the measured scalar field.

Capability, with room for expansion

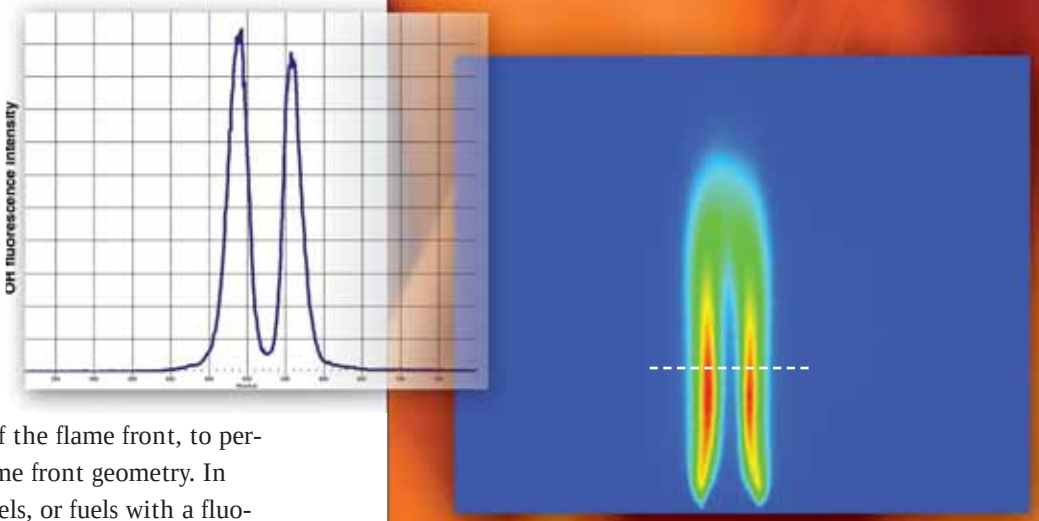
Featuring a complete selection of hardware, including a range of intensified and un-intensified cameras and wavelength-tunable dye laser configurations, the TSI combustion PLIF system is the state-of-the-art solution for your combustion imaging needs. The combustion PLIF system can be easily upgraded to

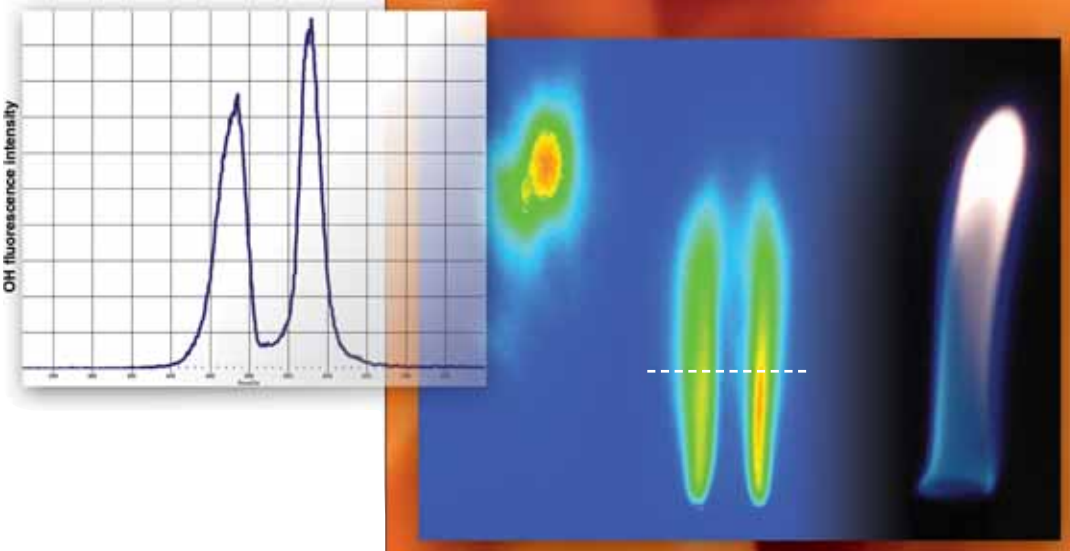
allow other measurement techniques, such as particle image velocimetry (PIV) for measuring the global velocity field and global sizing velocimetry (GSV) for simultaneous measurements of droplet size and velocity. Specialized spatial calibration routines allow these results to be analyzed in the flow-field coordinate system, for rapid comparison and correlation of multiple measured parameters.



Sample Measurements

Sample measurements to the right show PLIF measurements in a propane jet flame. The changes in OH distribution can clearly be observed as the flame was varied from fully pre-mixed to a pure diffusion flame. PLIF measurements of C2 in the diffusion flame are also shown. In other applications, the OH radical species distribution can be used as a flame front marker, and can be used to identify burned and unburned regions in the image field. Applying the image processing tools available in ***INSIGHT 3G*** allows isolation of the flame front, to permit quantitative analysis of the flame front geometry. In other measurements, fluorescent fuels, or fuels with a fluorescent tracer species added, can be used to visualize the fuel distribution and fuel consumption, and in many cases to quantify the local fuel concentrations. The emission and collections wavelengths of the system can be optimized for the imaging of other species such as CH, NO, and CO, to name just a few. Tracer species such as acetone exhibit strong temperature dependence of the fluorescence signals for certain excitation wavelengths, and can thus be used to gather information about the temperature field within the combustion region.





System

The combustion PLIF system can be viewed as several interacting sub-systems, including the illumination, imaging, and control & analysis subsystems. The illumination sub-system consists of the laser and associated optics. Typically, a Nd:YAG pumped dye laser is used, in order to provide the wavelength flexibility needed to excite the broad range of fluorescent species commonly investigated in combustion PLIF experiments. TSI works closely with Quantel Inc. to offer a range of tunable dye laser configurations (pictured above) that are both easy to operate and also provide the needed capability and flexibility for even the most challenging combustion PLIF measurements. The imaging sub-system includes the CCD camera, as well as any imaging optics, including specialized camera lenses and filters to allow wavelength selective imaging of specific species in the flow. Our ***INSIGHT 3G*** platform is built for expansion, allowing rapid incorporation of new cameras as technology evolves. TSI therefore supports the widest range of high sensitivity, low noise, intensified or un-intensified, and wide spectral range cameras.

The control and analysis sub-system includes the computer and timing electronics, as well as the ***INSIGHT 3G*** software package to control all hardware components, organize data, and perform image analysis, processing, and display routines. ***INSIGHT 3G*** features not only the wide range of image analysis and arithmetic algorithms and the complete flexibility of user-defined algorithms described previously, but also a range of additional capabilities, including locking measurements to external event triggers and collection of external analog data, such as laser pulse energy, temperature or pressure, to associate with the PLIF data.

Specifications

The configuration and specifications of individual systems vary according to the specific measurement needs, as choice of laser and camera models depends upon the experimental objectives. TSI works closely with every customer to ensure that the optimal system configuration is chosen to satisfy not only immediate measurement needs, but also to allow for simple expansion as measurement needs evolve.

Specifications subject to change without notice.
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TSI Incorporated
Headquarters—Tel: +1 651 490 2811 **Toll Free:** 1 800 874 2811 **E-mail:** fluid@tsi.com
UK **Tel:** +44 1494 459200 **E-mail:** tsiuk@tsi.com
France **Tel:** +33 491 95 21 90 **E-mail:** tsifrance@tsi.com
Germany **Tel:** +49 241 523030 **E-mail:** tsigmbh@tsi.com
Sweden **Tel:** +46 8 595 13230 **E-mail:** tsiab@tsi.com
India **Tel:** +91 80 41132470 **E-mail:** tsi-india@tsi.com
China **Tel:** +86 10 8260 1595 **E-mail:** tsibeijing@tsi.com
For current information **www.tsi.com**

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