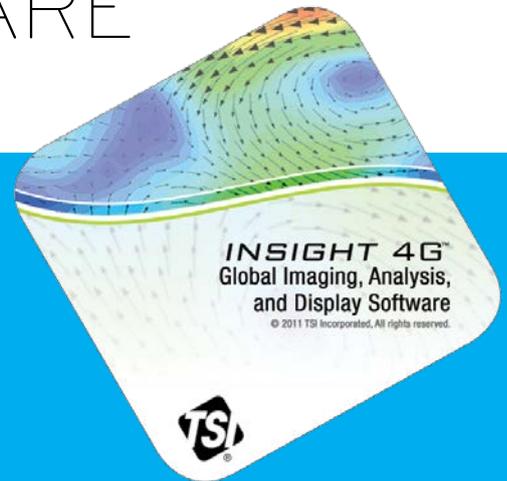


# INSIGHT 4G™ GLOBAL IMAGE, ACQUISITION, ANALYSIS, & DISPLAY SOFTWARE



Insight 4G™ Version 11.1 Global Image Acquisition, Analysis and Display Software improves on the legacy established by the industry-known Insight software package by TSI Incorporated. Faster, more robust, and with added capabilities, Insight 4G is a complete Particle Image Velocimetry (PIV) software platform operating on Windows® 7 64-bit operating systems capable of controlling a wide range of hardware and quickly analyzing results.

Insight 4G contains full hardware control from the user interface, meaning that once the hardware is turned on, image capture synchronization is controlled completely through the software. In addition, to hardware control, Insight 4G performs all types of velocity and intensity analysis with the latest state-of-the-art algorithms for 2D PIV, PTV, StereoPIV, TSI-patented TR-PIV, as well as size shape analysis (SSA), Global Sizing Velocimetry (GSV), Spray Patternation analysis, PLIF and Combustion PLIF.

#### Latest Features

- + Analysis of uncertainty of PIV Processing.
- + Support GPU to work with
- + CPU for processing speed increase
- + Dynamic morphological (DMM) masking of object in the image field captured by PIV.
- + Features or vortex tracking to explore flow structure.
- + Mid- and post-triggering to capture desirable image sequence for any non-triggered events.

#### Applications

- + Hydrodynamic
- + Aerodynamic
- + Spray Diagnostic
- + Turbulence Research
- + Combustion Research
- + Fundamental Research and Development

#### CAPABILITIES

##### Particle Image Velocimetry (PIV)

##### PIV Uncertainty using the Peak Ratio (PR) method

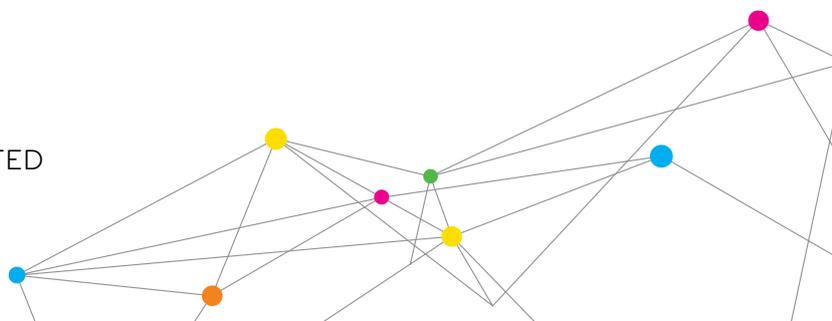
- + Provides the uncertainty bound of the velocity magnitude
- + Takes a global approach to uncertainty
- + The correlation map includes information about many sources of error, article dropout, background noise, particle response, etc.
- + Computationally inexpensive.
- + Does not require previously calculated vector nor any user input.
- + Produces accurate uncertainties irrespective of user experience
- + Calibration coefficients have already been calculated for use in Insight 4G

##### GPU Processing

- + Insight 4G is GPU accelerated and coded with CUDA®, providing processing speed up with GPU and CPU simultaneously
- + Insight 4G runs state-of-the-art multi-core CPUs concurrently with NVIDIA® GPU cards for fast image and PIV processing
- + Insight 4G implements massively parallel algorithms with tens of thousands of threads, delivering a high performance computing experience
- + Available for image preprocessing (up to 80X faster) and PIV & Stereo-PIV processing



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### **Time-Resolved PIV**

- + High speed, high repetition rate PIV for capturing the temporal evolution of structures within a flow.
- + Cross-correlation image analysis method for achieving velocity fields in a planar region of a flow.

### **Off-Axis PIV**

- + Image-dewarping PIV performed with the camera at an angle to the light sheet, used for situations where the 90° camera angle is not possible, or does not give sufficient light scattering.

### **Super Resolution Particle Velocimetry (SRPV)**

- + TSI's particle tracking algorithm combines the best features of PIV and particle tracking to obtain vector fields with the highest possible spatial resolution. (Keane et al. 1995)

### **MicroPIV**

- + Patented technology licensed by TSI from its inventors for the measurement of velocity in flows at the micron scale.

### **StereoPIV Module:**

- + Two-camera PIV allowing measurement of three-dimensional velocity in a planar region of the flow. (Soloff, et al. 1997 and Bjorkquist, 1998)
- + Stereo auto-mapping for correcting stereo calibration.
- + Autocalibration for geometric correction of Stereo PIV calibrations (Bjorkquist, 2002)

### **Size Shape Analysis (SSA) Module**

- + Imaging technique that measures the size, shape, and velocity of particles or objects.

### **Global Sizing Velocimetry (GSV) Module**

- + Interferometric technique for measuring the diameter and velocity of transparent droplets.
- + Optical technique for characterizing the global geometric properties of a spray, such as spray angle and patterning.

### **Planar Laser Induced Fluorescence (PLIF) Module**

- + Fluorescence technique for measuring scalar quantities in a flow such as pH, temperature, and species concentration.
- + Combustion PLIF Module Diagnostics of species from combustion characterization.

## IMAGE CAPTURE AND HARDWARE CONTROL

### **Hardware Control**

- + Full camera control for a variety of CCD, CMOS, and sCMOS cameras used for both low and high speed cameras for image straddling, fluorescence, backlighting, interferometry, etc.
- + Capture capabilities for simultaneous PIV-PLIF.
- + Area of interest capture for reduced image size.
- + Full laser control for Nd:YAG, Nd:YLF lasers, and Dye lasers for low and high repetition rates.

### **Additional Hardware Control**

- + Laser pulse energy meter, up to 6-axis traverse control and IO board for external data.
- + External triggering for synchronization with your experiment.

### **Data Management**

- + Open access to data. Image output in raw tiff format (no image 'compression') and vector output in ASCII text, stored in standard Windows® directories, no proprietary formats. Full and simple access to all data, no 'data export' required.
- + Distributed processing for utilizing multiple computers for processing large data sets. Included in standard Insight 4G, no additional 'upgrade' required.
- + Straightforward image calibration.
- + Software easily upgradable from 2D PIV to any of the other processing modules.

## IMAGE PROCESSING CAPABILITIES

### **Image Pre-Processing**

- + Simple, visual macro programming of image pre-processing steps.
- + Background removal in one step.
- + Dynamic and static masking.
- + Image pre-processing routines for phase separation.
- + Algebraic operations including addition, subtraction, multiplication, division, grayscale inversion, rotation, and masking.
- + Image binning.
- + Image filtering (with user-variable kernel parameters) including Gaussian, LaPlacian, LaPlacian of Gaussian, local mean, local median, local range.
- + Image generation from a sequence, such as minimum, average, or maximum intensity.
- + Image deformation including cardinal, bilinear, bicubic, and nearest neighbor, with user-selectable windowing methods (Hamming, Blackman, Hann, Flat-Top).
- + Dynamic background removal.
- + Velocity masking.

### **PIV Processing**

- + Uncertainty analysis of PIV Processing based on Peak to noise Peak Ratio (PPR).
- + Grid Engines including Nyquist and deformation grids.
- + User selectable interrogation spot sizes for both primary and final spots.
- + Spot mask engines including Gaussian Mask, Zero Pad Mask, and No Mask.
- + Correlation engines including Direct Correlation and FFT Correlation.
- + Standard and advanced processors such as Deformation Processor, Ensemble Correlation, and Double Correlation (Keane, Adrian 1990 and 1992) (Keane et al., 1995) (Wereley, Meinhart, 2000 and Wereley, Gui, 2003).



- + Complete access to relevant processing parameters for each processor such as pixel shift, number of passes, SNR ratio, minimum average spot intensity, and more.
- + Multithreaded processors for utilizing all computer cores.
- + Distributed processing for utilizing multiple computers.
- + Particle Tracking Velocimetry (PTV) included with standard Insight 4G.
- + Dynamic correlation peak analysis for SNR, maximum displacement, and second peak substitution.

### **PIV Post Processing**

- + Global Velocity validation including absolute max/min range velocity, standard deviation with user-defined tolerances.
- + Local velocity validation including Median Test, Mean Test, and Universal Median Test, with user-defined neighborhood size and tolerance.
- + Optional bad vector replacement by secondary correlation peak, local mean or local median.
- + Vector conditioning (low pass filtering) of velocity fields with user defined Gaussian filter with user defined size and sigma.
- + Simple, visual macro programming of post-processing steps.

### **PLIF Processing**

- + Temperature, concentration, pH, species, and other scalar measurement capabilities.
- + Combustion PLIF processing.
- + Simultaneous PIV-PLIF measurement and analysis capability.
- + In-situ calibration method correcting for spurious background signals, noise, spatial and temporal variability in illumination, and variability in individual pixel response.
- + Ratiometric, linear fit, or user-defined processing methods.
- + Available correction for laser pulse to pulse variation.
- + Laser attenuation correction.
- + Background image removal.

### **SSA Processing**

- + Determines pixel size of particles including: diameter, circularity, center of mass, area, Feret's diameter, perimeter, etc...
- + Tracks particles in space for determination of the velocity.
- + Subbranching for phase separation analysis.

### **GSV Processing**

- + FFT analysis of interference fringe pattern for determining droplet diameters from 10 to 500 microns.
- + Fringe tracking allows determination of velocity.

### **Super Resolution Particle Velocimetry Processing**

- + Particle identification and tracking.
- + Utilizes PIV correlation as a 'first guess' in obtaining particle-resolved velocities.
- + Highest possible spatial resolution through the determination of individual particle velocities.
- + Gives particle image size and associated statistical properties.

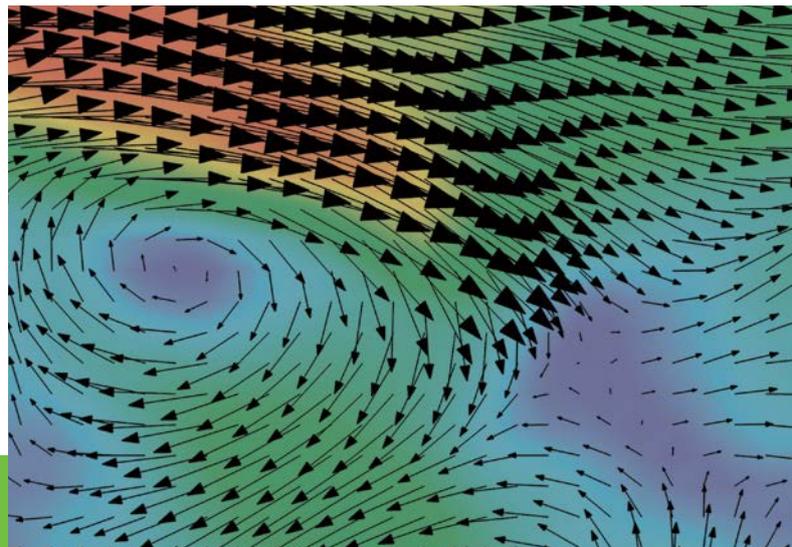
## **DATA DISPLAY AND STATISTICS**

### **TecPlot**

- + Free copy of TecPlot included with every copy of Insight 4G.
- + Extensive data display options including contouring, streamlines, vectors, shading, translucency, data normalization. (non-dimensionalizing the data), reference velocity field subtraction (e.g. subtract average field), etc...
- + Higher order statistical analysis such as mean, standard deviation, turbulence intensity, Reynolds stresses, velocity gradients, vorticity, strain rate, etc...
- + Vector/Contour plots, scatter plots, histograms.
- + Movie/animation generation.
- + User-defined variables.
- + Vortex tracking and feature tracking for TR-PIV.

### **MATLAB Dynamic Runtime**

- + MATLAB Runtime included with every copy of Insight 4G.
- + Time and spatial analysis for analyzing time-series velocity data, correlation, spectra, and Fourier series analysis.
- + Proper Orthogonal Decomposition (POD) analysis for extracting major/minor features of the flow.
- + Statistical analysis such as mean, standard deviation, turbulence intensity, Reynolds stresses, velocity gradients, vorticity, strain rate, dissipation, etc...
- + Movie/animation generation.
- + Vector/Contour plots.

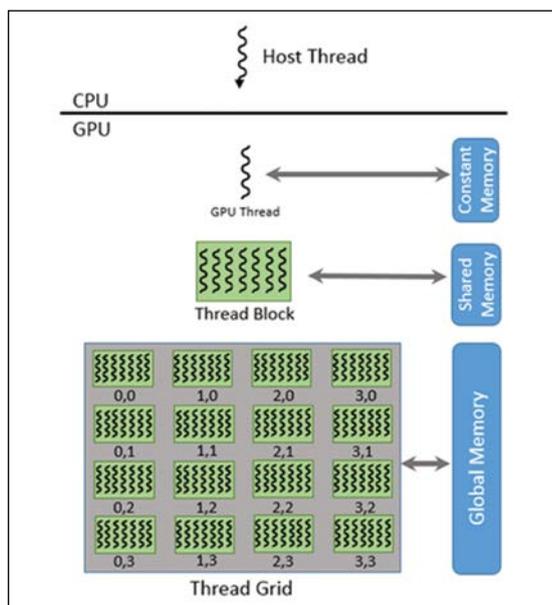


# SPECIFICATIONS

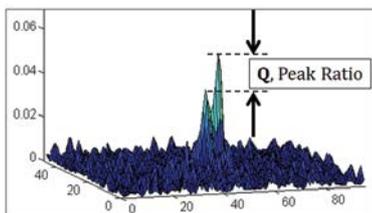
## INSIGHT 4G™ GLOBAL IMAGE, ACQUISITION, ANALYSIS, & DISPLAY SOFTWARE

| Base Software    |  |
|------------------|--|
| Insight 4G       | This base software is needed for a new system  |
| Insight 4G-MOD   | This base software is needed when additional modules are required.<br>It is used for upgrading system capability for previously purchased system (with the Insight 4G purchased)                       |
| Insight 4G-UP    | This base software is used for upgrade from old versions of Insight 3G and 4G. Modules used with the old version of Insight 3G and 4G remain compatible with Insight 4G and need not be ordered again. |
| Insight 4G-11-UP | Upgrade from older version of Insight 4G to the new version of Insight 4G Version 11   |

| Module          | System |           |        |           |               |      |     |     |
|-----------------|--------|-----------|--------|-----------|---------------|------|-----|-----|
|                 | PIV    | Micro PIV | TR-PIV | StereoPIV | TR-PIV Stereo | PLIF | SSA | GSV |
| Module4G-2DPIV  | +      | +         | +      | +         | +             |      |     |     |
| Module4G-STRPIV |        |           |        | +         | +             |      |     |     |
| Module4G-PLIF   |        |           |        |           |               | +    |     |     |
| Module4G-SSA    |        |           |        |           |               |      | +   |     |
| Module4G-GSV    |        |           |        |           |               |      |     | +   |



PGUs have a low per-core throughput, but a high number of cores, making it the choice for SIMD (Single Instruction Multiple Data) algorithms, such as PIV. Using each type of technology simultaneously achieves faster results.



PIV uncertainty based on correlation peak ratio

TSI serves the Global Fluid Flow Research community, through our direct offices and channel partners; TSI is committed to providing the lightest quality products.

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- Wereley, Gui (2003) A correlation-based central difference image correction (CDIC) method and application in a four-roll mill flow PIV measurement, Experiments in Fluids 34, pp.42-51.



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