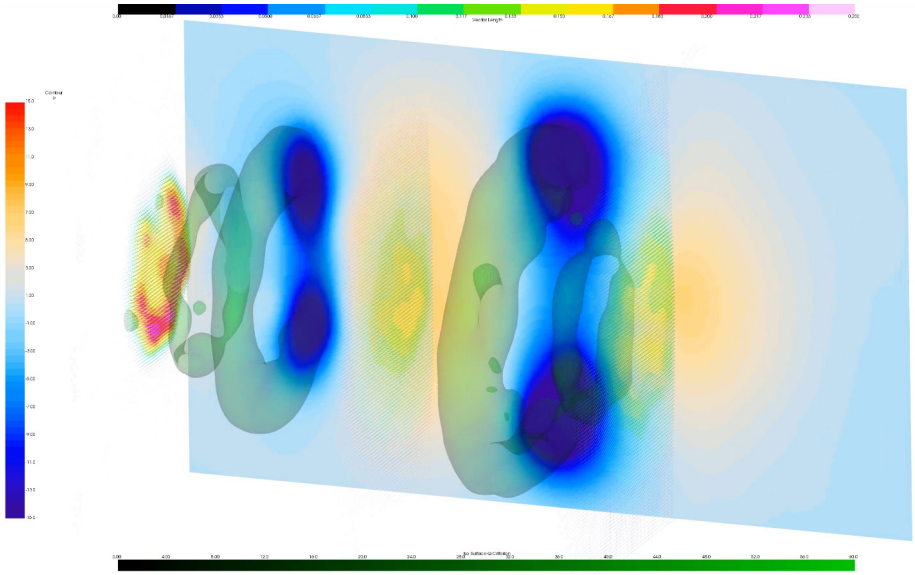
SOLUTION SHEET

Volumetric Velocimetry systems

The complete solution to understand your 3D flow phenomena



Volumetric PTV measurement of an accelerating pulsed jet interpolated onto a regular grid with computed pressures.

Quantify 3D flows with 3D measurements in a volume

Volumetric Velocimetry (VV) is a non-intrusive, optical based measurement technique providing researchers with a complete understanding of the dynamics of transparent fluids. With decades of continuous developments and innovative solutions for fluid measurements, Dantec Dynamics is your ideal partner for Volumetric Velocimetry.

Thanks to our wide selection of standard and customized hardware coupled with our powerful imaging software solution DynamicStudio, you can focus on your research rather than on the measurement technique.

Key benefits

- 3D Particle Tracking Velocimetry and 3D Tomographic PTV to follow individual particles in densely seeded flows
- State of the art Data Assimilation methods to use physical constraints to interpolate 3D PTV data onto a regular grid
- DynamicStudio has built-in tools and guides to simplify planning, setting up, calibrating and data processing of 3D methods
- Easy calibration tools and dedicated targets even for fully automated calibrations
- Patented Volumetric calibration refinement
- Tomographic PIV using multiple 3D reconstruction routines and the unique 3D Least Squares Matching to analyze the velocities
- Wide range of supported cameras from VGA to 25MP, and up to over 75000 fps
- Scalable workstations & GPU acceleration for faster processing
- Planar systems are easily upgraded to volumetric systems

The complete solution for volumetric flow measurements

Volumetric Velocimetry is an optical, non-intrusive measurement technique to characterize a flow within a volume. Hence, it is the natural extension of our range of planar Particle Image Velocimetry (PIV) techniques. It enables the user to measure the full 3D velocity information in transparent fluids.

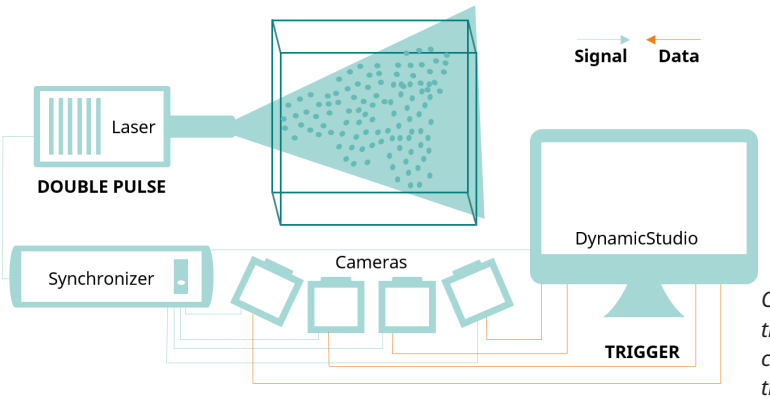
A volumetric system consists of typically four cameras (for some cases 2 can be enough) to record the particles at different viewing angles.

Scheimpflug mounts for the lenses are used to keep the entire illuminated volume in focus. To illuminate the volume, special laser optics or high-power LEDs have been developed to provide a uniform intensity profile along with several options for aspect ratio. A synchronizer is provided, to ensure all equipment like cameras, illumination and other components acquire the data at the exact same time instance, or if coupled with other optical based systems with an offset to remove illumination crosstalk.

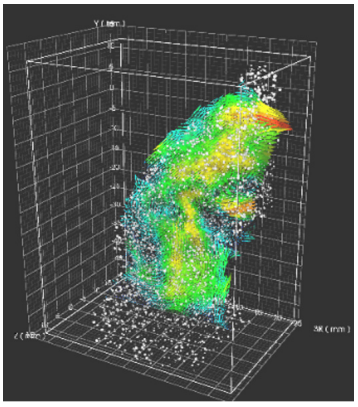
Due to the computational and hardware requirements of the system, a high-end workstation PC is used for recording, data handling, and analysis. For the user, the most important part of the entire system is the software - DynamicStudio.

With standard DEHS or helium filled soap bubbles one can measure lots of different scales in air flows, similarly in water many different solid seeding particles can be used to also measure small or large volumes.

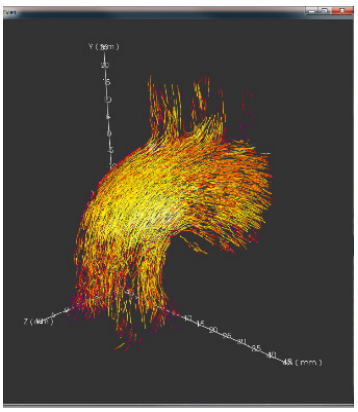
To assist you with the measurement, we provide easy to use guides and tools as well as an extensive online help, and multiple training videos that can be reached directly from withing DynamicStudio, allowing you to focus on the measurements and data analysis. The built-in tools provided to analyze and visualize the resulting 3D velocity information are invaluable for interpreting and understanding the complete flow phenomena. Both fluid mechanics researchers and industrial users will find the tools needed to best meet their measurement goals with the Volumetric Velocimetry solution.



Overview of the different components, timing and data flow.



3D Flow from 3D LSM inside the silicone model of an aortic root behind an artificial heart valve. The white blobs show the reconstructed particles and the vectors show the flow behavior. The result from 3D LSM is on a Eulerian equidistant grid.



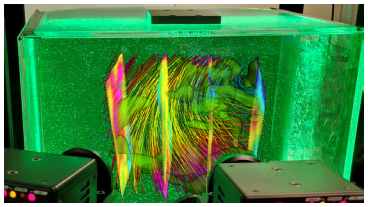
3D Flow from 3D Particle Tracking inside the silicone model of an aortic root behind an artificial heart valve. Lines show the trajectories of the measured particles with the color code representing their velocity. The result of the PTV is Lagrangian tracks of particles. [1])

Software

DynamicStudio enable you to work with the best suited analysis approach for your type of application. You can choose between different 3D Particle Tracking methods, todays standard, or unique 3D LSM based routines coupled with various reconstruction approaches. Furthermore, the PTV results can be coupled with Data Assimilation methods, which are smart interpolation methods, that are coupled with physical regularizations to remove outliers, enhance the spatial resolution, compute pressure fields, and vortex criteria.

For the ease of use DynamicStudio has guides and tools to support you during your work starting from planning the measurement, for camera alignment and focusing, until the final data export. Fully automated calibrations or innovative free hand 3rd order polynomial calibration along with the proven and patented Volumetric Calibration Refinement help you to get the best out of your data by offering the best possible calibrations!

Advanced modal analysis is possible with three methods: Proper Orthogonal Decomposition (POD), the recent award-winning multi-scale POD (mPOD) or Oscillating Pattern Decomposition (OPD), and finally the Modal Filter acting as a fully automated filter to detect outliers. Easily exchange your data, or write your own post processing routines using MatLab, Octave or Python links. For visualizations, or other data processing, DynamicStudio offers a wide range of export formats to Tecplot, ParaView or csv text data.



3-Camera time resolved 3D-PTV system to study mixing.

Hardware

The analysis routines are only a part of the VV solution. To complete the measurement chain and meet the needs of a wide range of measurement applications, a corresponding variety of hardware choices is required.
To this end, Dantec Dynamics offers a complete line of Volumetric Velocimetry hardware including; cameras, camera accessories, synchronizers, light sources, and volume illumination optics. With these tools, we can design the correct configuration to meet the temporal and/or spatial resolution requirements needed to investigate your flow phenomenon properly. To simplify the setup and ensure the hardware devices are configured correctly, these are auto-detected in the DynamicStudio software, including most of the light sources selected during the initial setup.



FlowSense FCX camera with lens mounted on a 1-Axis Scheimpflug Mount.

Cameras and lenses

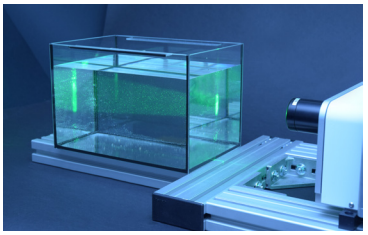
The Dantec Dynamics portfolio includes the widest range of CCD-, sCMOS and CMOS cameras enabling you to select the camera to match flows with over 75000 frames per second (@ 1 MP), or to resolve small scale phenomena with resolution of up to 25 MP. Select a lens to optimize the magnification and field-of-view (FoV) to fit the dimensions of the test facility. For Volumetric Velocimetry configurations, the cameras need to be positioned at an angle to the light-sheet or volume illumination. To keep the entire FoV in focus we need to have the sensor plane and camera lens at an angle to each other. This is accomplished by using our specially designed Scheimpflug mounts.



SpeedSense KT lens mounted on 2-Axis Scheimpflug Mounts.

Illumination sources

To match the applications need and camera specifications, a wide range of illumination systems are available from low cost, efficient, and safe LEDs up to high power and/or high frequency pulsed lasers. Typical VV illumination requires a flat intensity profile with a thickness and aspect ratio determined by the size of the test facility and/or object in the flow. To this end, Dantec Dynamics offers several options to form the TopHat volumetric illumination which is matched to the laser type and beam diameter. To deliver the laser beam safely to where it is needed, we offer several light guiding solutions.



Time Resolved Laser with Volumetric illumination system.

Synchronizer

The synchronizer ensures that all the hardware in the VV measurement chain perform their individual tasks at exactly the right time. The synchronization unit also enables the simultaneous data acquisition from other external devices used in the test setup. The synchronizer can be configured to enable remote acquisition from the PC providing the user with additional flexibility. We offer different synchronization units with different performance levels and upgrade possibilities, for instance the TrueTime to measure the individual pulse delay of every single laser pulse of a measurement. With USB and GigE interfaces they are easy to set up and with up to 32 channels, you will literally never run out of connections.



Large scale LED solution, single LED offers a cross section of 375mm x 125mm.

With accuracies below 50ps and resolutions below 1ns, together with analog in and outputs options for cyclic synchronization, our synchronizers represent state-of-the-art technology. A default or user-defined connectivity diagram is provided in the software showing the way that the synchronization cables are to be connected. For additional flexibility, the user can create and add custom devices such as pulse receivers to the measurement chain.



High Performance Synchronizer with up to 32 channels.

ActiveTarget

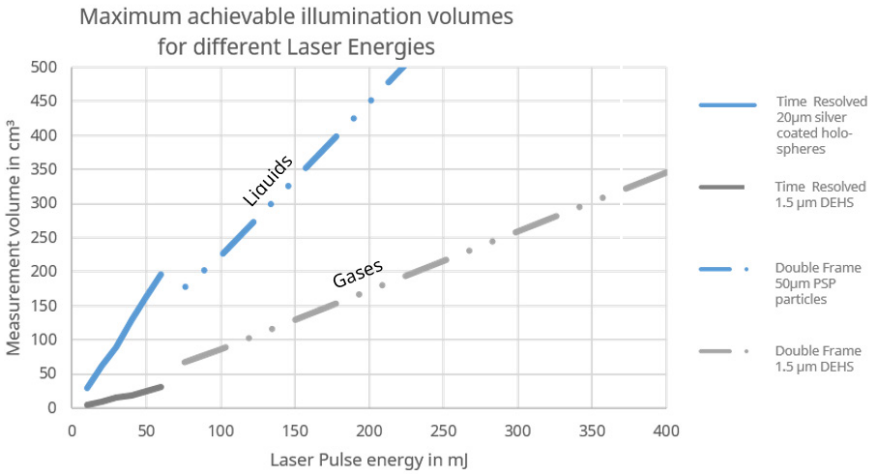
With the unique and actively lit ActiveTarget coupled with its traverse, calibration is very automated, fast and highly reproducible. The target consists of a 20x20 LEDs which are actively lit. Just point the camera on it, set the focus and the exposure time, tell the system the depths of the volume you want to calibrate and with a push of a button you get highly accurate calibrations with down to 0.05 px average reprojection error.
With an ActiveTarget and a motorized traverse, it is possible to acquire calibration images at different z-locations fully automatically. The interface just needs to know how many images are required and in which locations. The result can be an accurate final computed calibration, or the acquired raw images, ready for calibration, if storing the images is preferred. The traverse can be combined with any target.

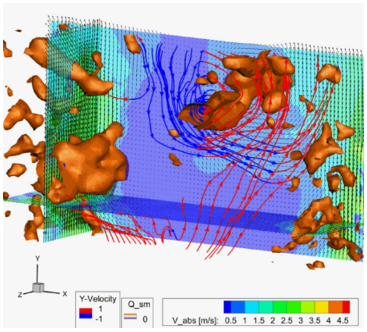


Active Target with 20 x 20 LED markers for easy and accurate calibration.

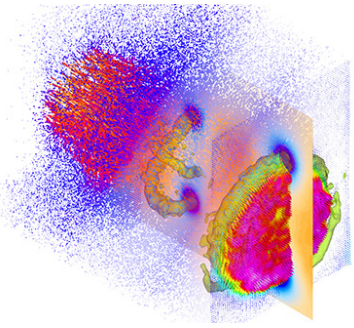
Achievable measuring volumes

The achievable measuring volume can be estimated from the following diagram. These estimates may vary with different camera types and camera arrangements. In air, often helium filled soap bubbles can be used push the measurement volume from a cm^3 towards $1m^3$. Often large LEDs are also used to illuminate large volumes in air or in water, their only drawback is the long exposure time needed to properly illuminate the particles. At the same time small volume µ-Fluidics can be realized in the range of a mm^3 to about a cm^3 depending on the used optical components.





Flow in the center of a low swirl burner, slices show the velocities, stagnation point is highlighted by the stream traces and swirls in the shear region are indicated by Iso-contours of the Q-criteria.[2])



PTV and Data Assimilation overlay of a jet flow.

1) Hegner, Hess, Brücker (2015): "Volumetric 3D PIV in heart valve flow" Conference: 11th Int. Symposium Particle Image Velocimetry - PIV15, Santa Barbara, California

2) Petersson, Hess and Alden (2017): "High Speed 3D flow analysis on a low swirl burner using tomographic reconstruction and 3D LSM" - ISPIV 2017

DANTEC DYNAMICS Turn Measurements into Knowledge

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NOVA INSTRUMENTS