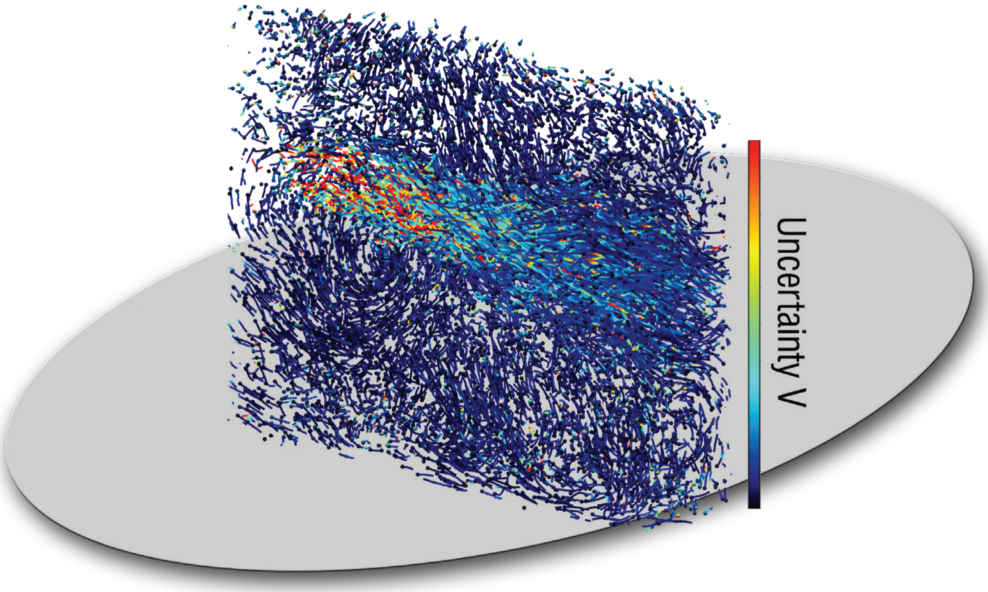
PTV/LPT Uncertainty Quantification

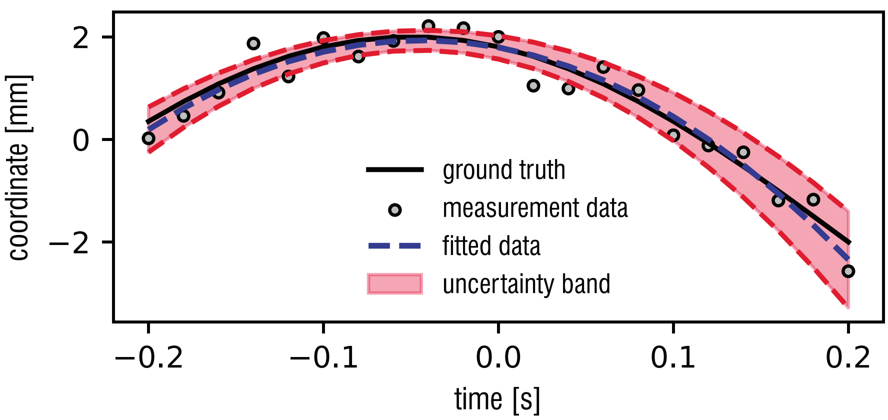
Position, velocity and acceleration uncertainty for every particle

When reporting experimental results it is crucial to include the associated measurement uncertainties in order to perform reasonable comparisons between other measurements or to determine the overall quality of the conducted research. For LaVision's **Particle Tracking Velocimetry** (**PTV**) and unique **Shake-the-Box** package, the software includes the quantification of **instantaneous position, velocity and acceleration uncertainties** for each reconstructed particle in time-resolved measurements.



Linear regression analysis

Within **DaVis** the derivation of velocities and accelerations from the particle trajectories is done by the performant and fast Savitzky-Golay filter [1]. This filter can be interpreted as a sliding polynomial regression operation on each track. For this linear regression well-established analysis tools can be utilized to **quantify the uncertainties** of the fitted regression coefficients. By intelligently shifting the filter window and the timing information for each particle, the **uncertainties for position, velocity and acceleration** can directly be obtained from these regression coefficients at any specified confidence level [2].



Linear regression analysis yields the uncertainty band along the complete particle trajectory.

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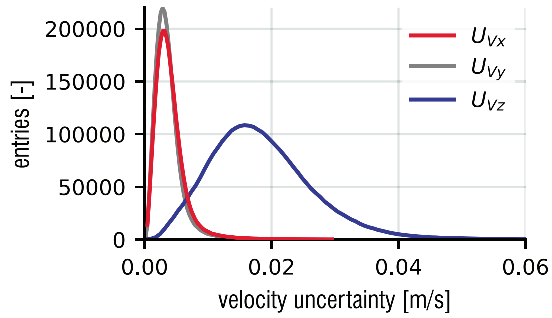
Uncertainty distributions

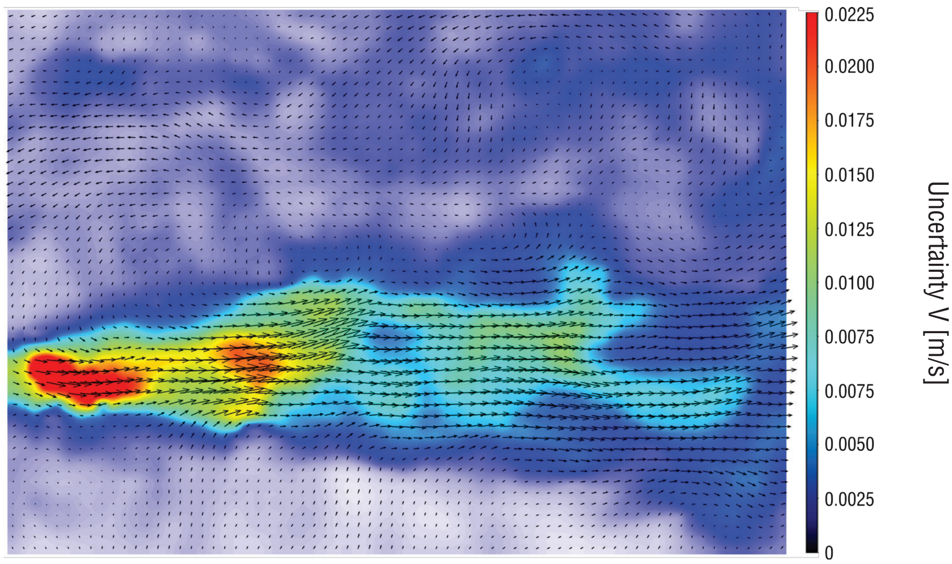
By having the uncertainty information of every particle, the global uncertainty distribution of each velocity component can be calculated. This offers a new tool to determine the performance of the measurement system. For example, when working with a very narrow viewing angle of the used multi-camera system, the increased uncertainty of the out-of-plane component can be clearly identified.



Velocity uncertainty distributions for each velocity component of a measurement set up with a narrow stereo base.

Uncertainty of binned data

With an advanced binning approach, **DaVis** offers the possibility to convert the Lagrangian trajectory data to a Eulerian velocity field.
During this conversion, the **velocity uncertainties** for each grid point can be calculated by a statistical analysis of the velocity distribution within each bin.



Velocity uncertainty field of a binned velocity field from a Shake-the-Box measurement

[1] Savitzky A and Golay M (1964). Smoothing and Differentiation of Data by Simplified Least Squares Procedures. Analytical Chemistry, 36(8), 1627-1639.

[2] Janke T and Michaelis D (2021). Uncertainty Quantification for PTV/LPT Data and Adaptive Track Filtering. 14th International Symposium on Particle Image Velocimetry, 1-4 August, Chicago.

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