On the Resolved Scales in a Turbulent Boundary Layer 
by Tomographic PIV and PTV aided by VIC+

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HIGHLIGHTS

- The VIC+ method is applied to a time-resolved tomographic PIV experiment in a turbulent boundary layer
- Vorticity, originally damped by 40% with PIV, is recovered to within 10% of a DNS reference with VIC+
- Results obtained by VIC+ provide additional detailing of vortex shapes, in comparison to tomographic PIV

ABSTRACT

Time-resolved tomographic PIV and tomographic PTV aided by VIC+ are applied in a turbulent boundary layer (Re, = 2038) measurement, and the resulting small scales flow properties, i.e. vorticity and dissipation, are compared. The VIC+ technique was recently proposed and uses the concept of pouring time into space to increase reconstruction quality of instantaneous velocity and vorticity. Tomographic PTV particle track measurements are interpolated to a dense grid, making use of both particle velocity and Lagrangian acceleration. Comparison of the vortical structures by visualization of isosurfaces of vorticity magnitude shows that the two methods return similar coherent vortical structures, but their strength in terms of vorticity magnitude is increased when using VIC+. Moreover, the results obtained by VIC+ (e.g. Fig. 1b) provide additional detailing of the vortex shapes, which suggests an improvement in spatial resolution in comparison to tomographic PIV (e.g. Fig. 1a).

Fig. 1 Close-up view of a hairpin structure from tomographic PIV (a) and VIC+ (b) at the same isosurface levels of vorticity magnitude (orange) and velocity (blue). Profile of wall-normal rms vorticity fluctuations (c).

Statistical evaluation shows that rms vorticity fluctuations from tomographic PIV are ~40% lower in comparison to a reference profile from a DNS simulation, while the VIC+ technique returns RMS vorticity fluctuations to within 10% of the reference for y > 20 (Fig. 1c). It is concluded that when time-resolved tomographic measurements are available, VIC+ can improve reconstruction quality of velocity and vorticity – also in actual experiments.