Tomographic PIV (Elsinga et al. 2006) has attracted much attention during the last years. A considerable development of the evaluation algorithms not only resulted in an improved reconstruction quality but also in an increased evaluation speed. Applications have been demonstrated in water flows as well as in air flows with short imaging distances (Schröder et al. 2008, Novara & Scarano 2011). Longer imaging distances are restricted to low spatial resolution applications (Kühn et al. 2011). In conclusion, tomo-PIV in contrast to stereo PIV still remains far from being a standard measurement tool for industrial wind tunnel campaigns. The main problems in such environments result from the large imaging distances in combination with vibrations transferred to the imaging equipment, which spoil sub-pixel accurate calibration and thus renders a sound volume reconstruction impossible. In addition, the illumination of the volume tends to be critical. Since tracer particles for air flows are required to have diameters around 1 µm, the scattered light intensity is low - especially when using high speed laser illumination. The present feasibility study takes a significant step towards the necessary scale-up and toughening for measurement campaigns in industrial wind tunnel environments.

The measurements have been performed at the acoustic wind tunnel Braunschweig (AWB), an open-jet closed-loop wind tunnel with a rectangular 0.8 m by 1.2 m nozzle exit and anechoic acoustic environment. An F16 profile (chord 300 mm, span 800 mm) in high-lift configuration (Ciobaca et al. 2009) is mounted between two side plates in the test section at an angle of attack of 17°. The wind tunnel flow is seeded with DEHS droplets and tripped to turbulent boundary layer flow on the upper surface of the flap in the gap right below the trailing edge of the main wing. A dual-cavity LEE LDP 200 MQG laser operated at 3 kHz with a pulse energy of 2 * 11 mJ is used to illuminate an area of 150 mm (stream wise) * 50 mm (normal to flap surface) above the suction side of the flap. Since - due to the high repetition rate - the pulse energy is significantly lower than in a low repetition rate system, the volume was limited to a thickness of 6 mm (chord wise). In this type of setup (‘fat sheet’), the volume information is used to gain the complete time-resolved 3-dimensional velocity gradient tensor. Two Photon APX-RS and two Photon SA-1 cameras equipped with Zeiss Contax 180/2.8 lenses record the measurement volume in forward scattering direction from below the test section at a distance of 1.5 m. A sequencer synchronizes the measurement system in frame-straddling mode, allowing pulse separations down to 5 µs.

Measurements have successfully been performed at free stream velocities of 40, 50 and 60 m/s, showing the transient features of the attached and separated flow. Parameter studies regarding seeding density, light sheet thickness and F-number have been conducted. An example evaluation is depicted in Figure 1, showing the velocity vector volume above the flap.

The promising results of the present study show a road towards the application of tomo-PIV in large scale industrial wind tunnels, aiming to finally establish this technique as a validated standard tool for wind tunnel measurements. The gained time-resolved volume data gives valuable information for the validation of prior (Ciobaca et al. 2009) and future CFD calculations.

References