Large field SPIV using separated light sheets in a spanwise plane applied to a turbulent boundary layer with vortex generators

J.M. Foucat\textsuperscript{1}, S. Coudert\textsuperscript{2}, C. Braud\textsuperscript{2}, C. Velte\textsuperscript{3}

\textsuperscript{1-2}: Univ. Lille Nord de France F-59000 Lille, EC Lille\textsuperscript{1}, CNRS\textsuperscript{2}, Laboratoire de Mécanique de Lille (UMR 8107)
Boulevard Paul Langevin, 59655 Villeneuve d'Ascq Cedex,
\textsuperscript{3}: Department of Wind Energy,
Technical University of Denmark - DTU
Nils Koppels Allé Building 403,
2800 Kgs. Lyngby, Denmark

* Correspondent author: jean-marc.foucaut@ec-lille.fr

**Keywords**: Stereoscopic PIV, Accuracy, Plane normal to the flow, Light sheet separation

The SPIV is nowadays a well established measurement technique for turbulent flows (Westerweel, Prasad). However, the accuracy is each time a new challenge when complexities are added in the flow such as strong gradients, strong out of plane motions and a large field. In the present work, we focus on measurements behind vortex generators embedded in a high Reynolds turbulent boundary layer where all these problems are encountered. These types of actuators are generally used in flow control to reduce pressure or viscous drag found in many applications such as aeronautics, wind turbines ... (Gad-el-Hak). From the use of two PIV systems, it is possible to obtain a large zone of overlap where precision of measurements will be investigated. This study gives guidelines for measurements of such flow configurations. The LML wind tunnel facility has been specially designed to study turbulent boundary layer at high Reynolds number. The 20 m long test section allows a boundary layer thickness of about 30 cm (Carlier and Stanislas). In this wind tunnel, an experiment was performed to characterize vortices made by specific vortex generators in the turbulent boundary layer. A large field Stereoscopic PIV in a plane normal to the flow was used. A solution to improve the accuracy, discussed in the present paper, is to separate the two light sheets of a distance corresponding to the mean dynamic. The Reynolds numbers based on momentum thickness studied was 17000.

![Fig. 1 Experimental set-up](image)

Figure 1 shows a top view of the set-up. The PIV system was imaged with two Stereoscopic PIV systems in order to enlarge the field of view. Each system was based on 2kx2k pixel cameras and 105 mm lenses. The field of view of each system is about 40 x 25 cm\textsuperscript{2}. Both systems were adjusted with a large overlap region in order to obtain, after merging, a final field of view of about 75 x 28 cm\textsuperscript{2}. These dimensions are comparable to the boundary layer thickness. In that plane, the spatial resolution is 2 mm (40 wall units). The large size (12 cm) of the overlap region allows us to study the accuracy of the PIV measurement. The present paper focuses on this accuracy and the influence of the light sheet separation by studying first the case without actuators.

The laser used was a BMI YAG system with 2 cavities which is able to produce energy of 220 mJ per pulse at a frequency of 12 Hz. Each SPIV system was adjusted with respect to the Scheimpflug conditions. The seeding was Poly-Ethylene Glycol micron particles. Figure 2 gives an example of result. The vectors correspond to the instantaneous in plane velocity components and the contour to the instantaneous streamwise (out of plane) velocity component.

![Fig. 2 Example of result](image)

As a conclusion, the utility of a sheet separation to improve the measurement quality is discussed in the paper. It is shown how a light sheet separation allows an optimization of the PIV dynamic range.

The outlooks are to characterize the physics of the streamwise vortices produced from vortex generators taking advantage of large scales of the turbulent boundary layer.


3.8.2