EXPERIMENTAL CHARACTERISATION OF A HIGH REYNOLDS NUMBER TURBULENT BOUNDARY LAYER SUBJECTED TO AN ADVERSE PRESSURE GRADIENT

S. Srinath[1,3], C. Cuvier[1,2], M. Stanislas[3], J. M. Foucaut[1,3], J. P. Laval[1,2], C. J. Kähler[4], R. Hain[4], S. Scharnowski[4], A. Schröder[5], R. Geisler[5], J. Agocs[5], A. Röse[5], C. Willert[6], J. Klinner[6], J. Soria[7], O. Amili[7], C. Atkinson[7]

[1]*Univ. Lille, FRE 3723 – LML,* [2]*CNRS, FRE 3723,* [3]*Centrale Lille, F-59000 Lille, France*

[4]*Bundeswehr University Munich, Germany,* [5]*DLR, Göttingen, Germany,* [6]*DLR Köln, Germany*

[7]*Monash University (Clayton Campus), Australia*

The observation of large-scale coherent structures in turbulent boundary layers has sparked great experimental and numerical interest. While most studies have focussed on channel flows and zero pressure gradient (ZPG) boundary layer flows, our understanding of wall turbulence under the influence of a streamwise pressure gradient is still quite limited due to the lack of sufficiently high Reynolds number data and large facilities to reach an equilibrium state where theoretical scaling laws can be relevant [1]. The length of these structures (7-14δ [2]) requires a large field of view and a high spatial resolution to measure all relevant spatial scales.

To resolve and characterize the structures in an adverse pressure gradient (APG) boundary layer, a set-up in the LML boundary layer wind tunnel was built using 16 sCMOS cameras (a consortium involving 4 teams under the framework of EuHIT) in order to perform large scale turbulent boundary layer measurements with appropriate spatial resolution [3]. The length of the 2D2C PIV measurement domain was 3.5m long and 0.25m high (see Figure 1) to ensure the possibility of capturing very large-scale structures with lengths more than 10δ. A total of 30000 images were recorded for two free-stream velocities of 5m/s and 9 m/s (corresponding to $Re_\theta \approx 10600$ and $Re_\theta \approx 17700$ at station 4 respectively) [4]. Figure 2 shows a snapshot of the streamwise velocity fluctuations with very long regions of low-speed and high-speed structures. The topology and dynamics of the large-scale turbulent structures under an APG will be presented. As a similar experiment with a large field of view (1.16m long and 0.3m high) was earlier conducted on a ZPG turbulent boundary layer at LML, the influence of an APG on these structures will be shown.

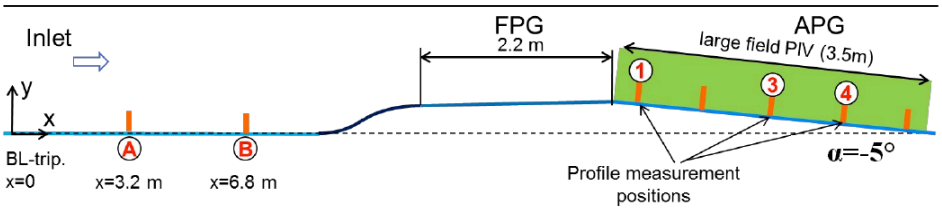

Figure 1. Schematic of the wind tunnel test section with the profile measurement stations and the large field APG.

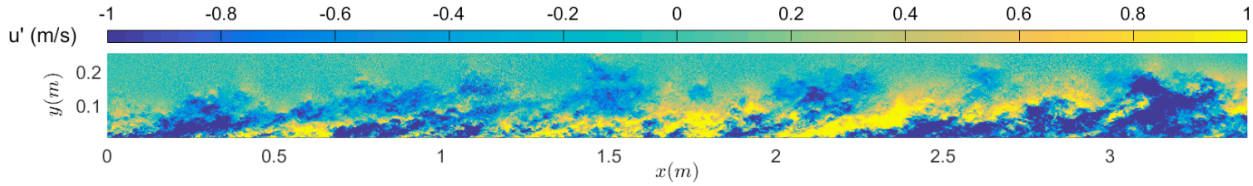

Figure 2. Snapshot of a streamwise fluctuating velocity field after merging the 16 PIV systems at 9m/s.

References

[1] L. Castillo and W. K. George. Similarity analysis for turbulent boundary layer with pressure gradient: outer flow. AIAA journal, **39.1**:41-47, 2001

[2] N. Hutchins and I. Marusic. Evidence of very long meandering features in the logarithmic region of turbulent boundary layers. J Fluid Mech, **579**:1-28, 2007

[3] Cuvier *et al*. A joint experiment for the characterization of a high Reynolds number decelerating boundary layer with advanced optical metrology. *Submitted to the Journal of Turbulence*.

[4] Database of the large field APG experiments: https://turbase.cineca.it/turbase/default/#/view_dataset/25