THE EVOLUTION OF TRANSITIONAL FLOW STRUCTURES ALONG A 3200 D PIPE IN THE DECAY AND GROWTH REGIMES

Ö. Ertunç, J. Krauss, H. Lienhart, H. Schweiger, H. Weber & A. Delgado
Institute of Fluid Mechanics, Friedrich-Alexander-University Erlangen-Nuremberg, Erlangen, Germany

Abstract The evolution of transitional flow structures along a 3200 D pipe in the decay and growth regimes are measured in a 3200 D structure tracking pipe flow facility. We report the statistics of the evolution for the probability of occurrence , characteristic lifetime, speed and length of the structures.

INTRODUCTION

In the last two decades, transition phenomena in pipe flow attracted increasingly many researchers owing to its non-linear behavior and the coherent structures occurring during transition [2, 7]. When a fully developed pipe flow is disturbed locally with an amplitude higher than threshold amplitude of transition, this disturbance might evolve a rich variety of structures along the pipe. There is critical Reynolds number (Re_{cr}) below which the disturbance either decays directly or first forms puffs and then decays further downstream in the pipe. Above Re_{cr}, the disturbance evolves to a puff and this puff grows continuously through splitting as the structure(s) flow along the pipe. After a certain Reynolds number ($Re_{slug} > Re_{cr}$) the disturbances evolve directly to slug structures [8, 5]. Recently we have developed a structure tracking method based on hot-wire sensors installed along the pipe [3]. This facility was shown to deliver consistent probability data decay and growth (splitting) of puffs. The same method is now employed along a 3200 D pipe, in order to increase the reliability of the data and the observation time which are especially important for splitting and lifetime analysis. The pipe is equipped with 36 hot-wire sensors. Velocity signals from one realization at $Re = 2500$ in Fig.1 shows the evolution of one disturbance along the pipe.

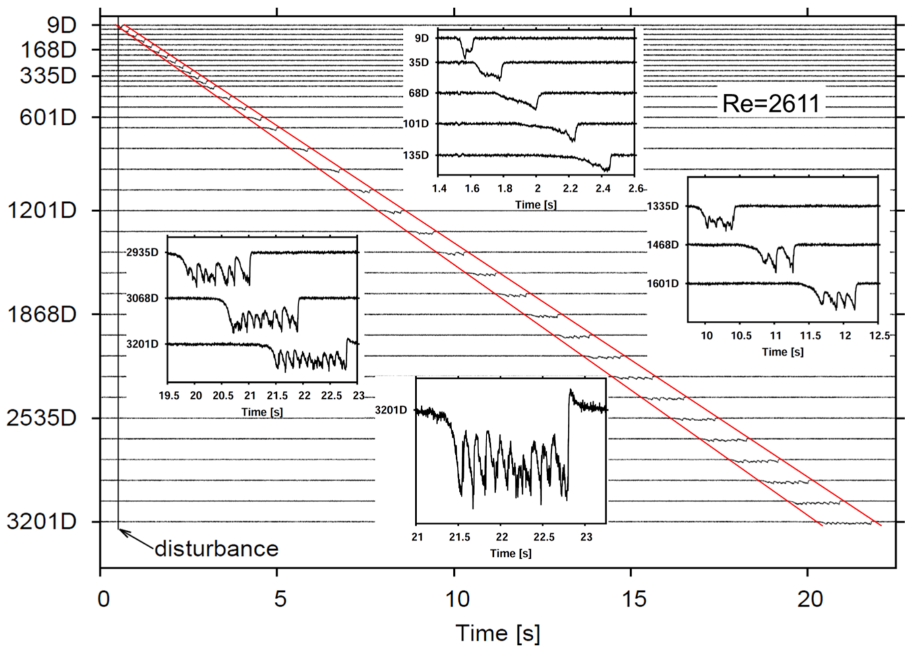

Figure 1. Velocity signals from one realization at $Re = 2500$ shows the evolution of the disturbance into along the pipe.

PRELIMINARY RESULTS

In the present study, we will report the statistics of the evolution of the structures in decay and growth regimes. For this purpose, 47500 realizations have been performed in the Reynolds number range between 1900-3000 until now. Experiments are being conducted to decrease the statistical uncertainty. In the statistical analysis, emphasize will be given to probability, characteristic lifetime, speed and length of the structures. Spatial evolution of occurrence probabilities of single puffs and splitting of a single puff into two puffs are shown in Fig. 2 for the growth regime. The lifetime depicts a shift towards a higher Re than that was suggested in the literature [4, 6, 1]. At the moment, we are looking for possible explanations for this deviation and these will be a part of this contribution.

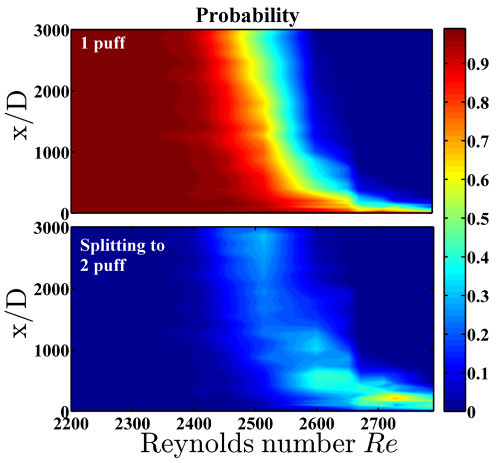

Figure 2. Spatial evolution of occurrence probabilities of single puffs and splitting of a single puff into two puffs in the growth regime.

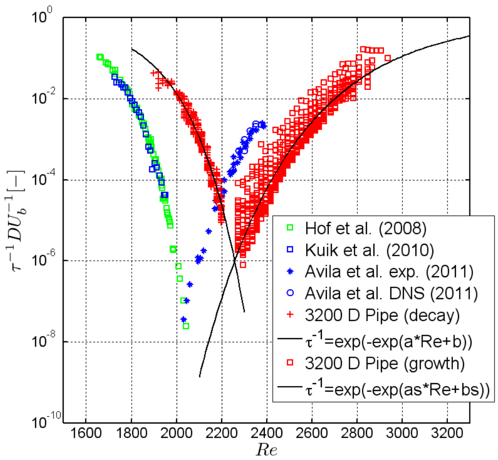

Figure 3. Comparison of characteristic lifetimes.

References

[1] K. Avila, D. Moxey, A. De Lozar, M. Avila, D. Barkley, and B. Hof. The onset of turbulence in pipe flow. *Science*, **333**(6039):192–196, 2011.

[2] B. Eckhardt, T. M. Schneider, B. Hof, and J. Westerweel. Turbulent transition pipe flow. *Annu. Rev. Fluid Mech.*, **39**:447–468, 2007.

[3] Ö. Ertunç, J. Krauss, H. Lienhart, P.R. Miranda, and A. Delgado. Tracking the transitional flow structures in low reynolds number pipe flow. *ETC-13 Warsav Poland*, 2011.

[4] B. Hof, A. De Lozar, D. J. Kuik, and J. Westerweel. Repeller or attractor? selecting the dynamical model for the onset of turbulence in pipe flow. *Phys. Rev.*, **101**(21), 2008. Cited By (since 1996): 22.

[5] J. Krauss, Ö. Ertunç, H. Lienhart, C. Ostwald, and A. Delgado. Evolution of transitional structures from puff to slug through multiple splitting in a pipe flow at low reynolds number. *Journal of Physics: Conference Series, ETC-13 Warsav*, **318**, 2011.

[6] D. J. Kuik, C. Poelma, and J. Westerweel. Quantitative measurement of the lifetime of localized turbulence in pipe flow. *J. Fluid Mech.*, **645**:529–539, 2010.

[7] T. Mullin. Experimental studies of transition to turbulence in a pipe. *Ann. Rev. Fluid Mech.*, **43**:1–24, 2010.

[8] M. Nishi, B. Ünsal, F. Durst, and G. Biswas. Laminar-to-turbulent transition of pipe flows through puffs and slugs. *J. Fluid Mech.*, **614**:425–446, 2008.