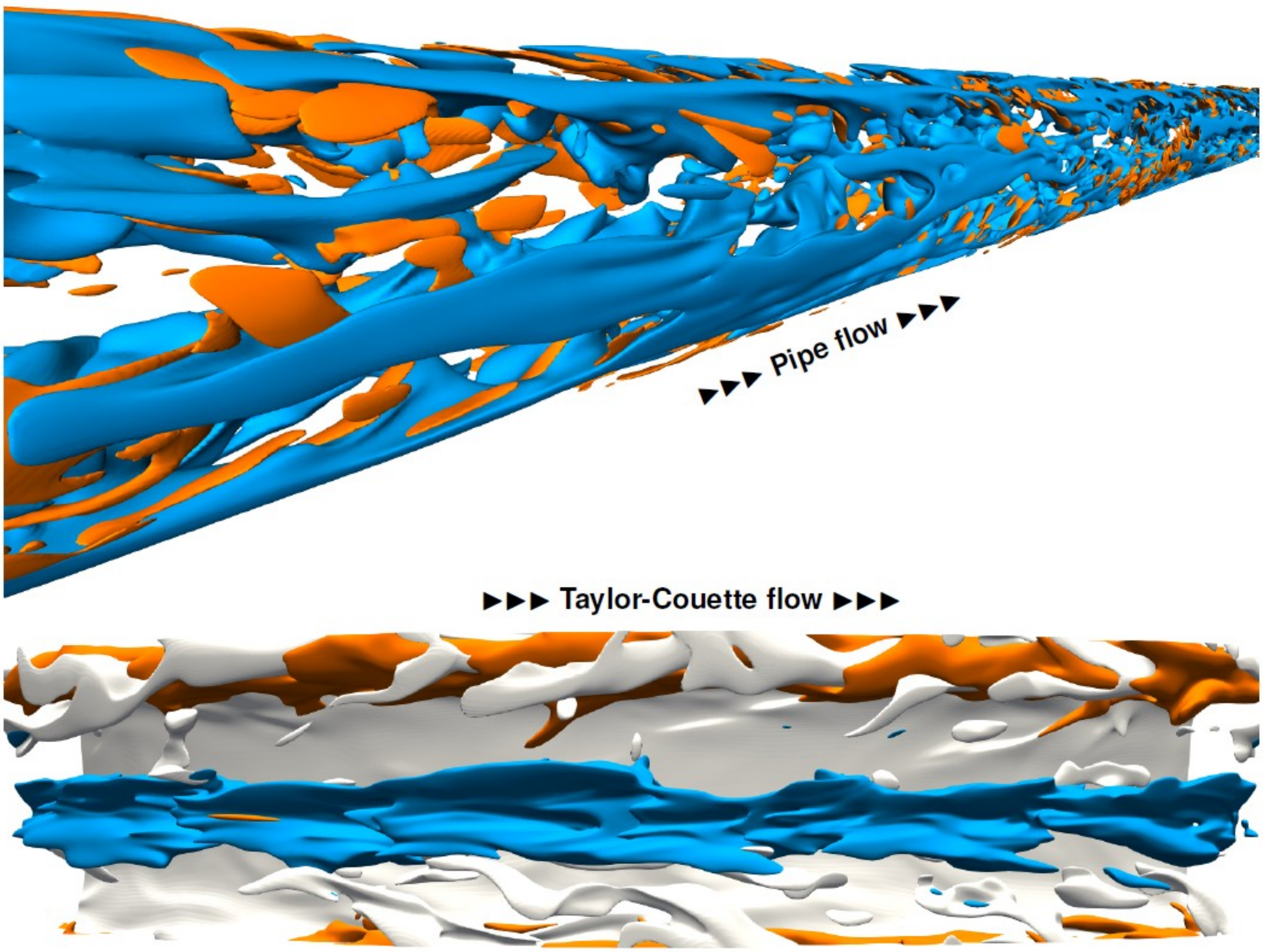
Coherent superstructures in turbulent pipe and Taylor-Couette flows

Fluid motions in nature and engineering typically feature large-scale coherent motions, so-called superstructures, which are strongly shaped by boundary conditions, geometry and source of driving. Turbulent superstructures carry a substantial part of the kinetic energy, they contribute to drag and they often dominate heat, mass and momentum transport properties of the entire fluid system. Hence, in order to go beyond state of-the-art modelling and control strategies of turbulent flows, superstructures must be correctly accounted for.



In this project, we will investigate the dynamics, energetics and transport properties of superstructures in two canonical set-ups: cylindrical pipe and Taylor-Couette flow. The latter one consists of a fluid confined between two rotating concentric cylinders, which we will consider mainly in the narrow-gap limit. First, we will determine whether superstructures harvest energy through coherent alignment of much smaller scales, or directly from the mean shear. We will achieve this by computing the inter-scale energy flux from direct numerical simulation data with a (spatial) filtering approach. Second, in order to aid the groups developing characterisation and detection methods within the Priority Programme, we will offer and maintain highly-resolved data sets, which will be adaptively reduced in spatial and temporal complexity using our filtering tools. With these methods, we will investigate the relationship between Lagrangian coherent structures and energy fluxes. Our work will build upon the network of collaborations established in the first funding phase and will allow bridging the current gap towards high Reynolds numbers.