# Vortex rings gone with the wind

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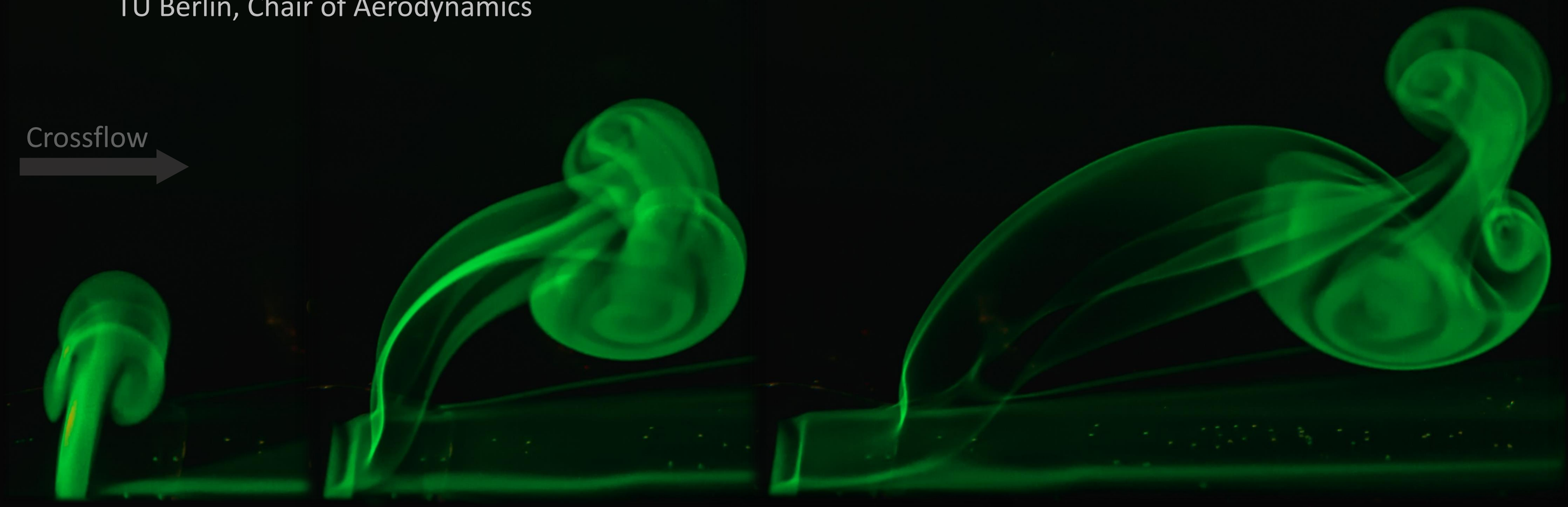


The mixing effectivity associated with jets ejected transverse into a crossflow can be enhanced by using a pulsatile velocity program. This is due to the generation of leading vortex rings. Here, we investigate a slit-shaped outlet ( $40\ \mathrm{mm} \times 2\ \mathrm{mm}$ ) and visualize the resulting three-dimensional vortex structures in a water tunnel.

As revealed by the time series shown above, the roll-up of the upstream vortex tube can be inhibited by the crossflow boundary layer. In contrast, the leeward vortex tube is very dominant and therefore mainly responsible for the entrainment of crossflow fluid.

The figure in the bottom right illustrates how the starting jet appearance is affected by the crossflow velocity. When the crossflow velocity is larger than in the time series shown above, the vortex impinges onto the wall downstream of the outlet. When the crossflow velocity is smaller, a tilted vortex ring is observed, and in the absence of crossflow, an elliptic vortex ring is generated despite the high aspect ratio outlet geometry.