

Supplementary material to: Transitional hypersonic flow over slender cone/flare geometries

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In this supplementary material, we provide, for the reader's reference, schlieren sequences showing typical behaviour (unless otherwise noted) for combinations of flow conditions and flare angles that were not included in the main manuscript. In each figure, an averaged image is presented at the top (with locations of PCB sensors indicated) to show the mean flow structures, and a sequence of reference-subtracted instantaneous images is included below. Estimated separation and/or reattachment locations are indicated by vertical dashed lines where relevant. The motion of prominent disturbances (second-mode or shear-layer) is depicted by vertical red bars, and radiation of disturbance energy to the external flow (typically along mean flow structures) is indicated with arrows.

Figure 1 shows the straight-cone ($+0^\circ$) case for Re45, while figures 2 and 3 show sequences for the $+5^\circ$ flare at conditions Re33 and Re52. Sequences for the $+10^\circ$ configuration at conditions Re33 and Re52 are provided in figures 4 and 5. In all of these cases, second-mode waves feature prominently. As noted in the main text, however, for the $+15^\circ$ flare at the lower two unit Reynolds number conditions, shear-layer disturbances became much more dominant; a relevant sequence at Re33 is shown in figure 6. At these conditions, second-mode wavepackets became far less frequent, though one such instance (for condition Re45) is presented in figure 7. As the wavepacket traverses the separation bubble (in the first two images), we note that its periodic structures seem to become more aligned with the shear layer and it subsequently appears to merge with the shear-layer waves. This imposes a periodic, wavy structure on the separated shear layer near reattachment in the final image of the sequence. Second-mode waves re-emerged as the primary disturbance at condition Re52, with shear-layer waves appearing only intermittently. As noted in the main article, several particularly intense bursts of turbulence were observed in the relevant experiment, which caused the separation bubble to collapse and reform in a transient process. The image sequence of figure 8 shows a wavepacket passing through the SWBLI during one such recovery event. The third image of the sequence shows radiation emanating from the head of the wavepacket along the flare shock as it reaches the flare (annotated with a red arrow). The wavepacket immediately enters a transitional state along the flare, as evidenced by the turbulent structures seen at around $X=427$ mm in the final image. This behavior is not, however, universal: the first image of the sequence shows a wavepacket on the flare which does not appear obviously transitional.

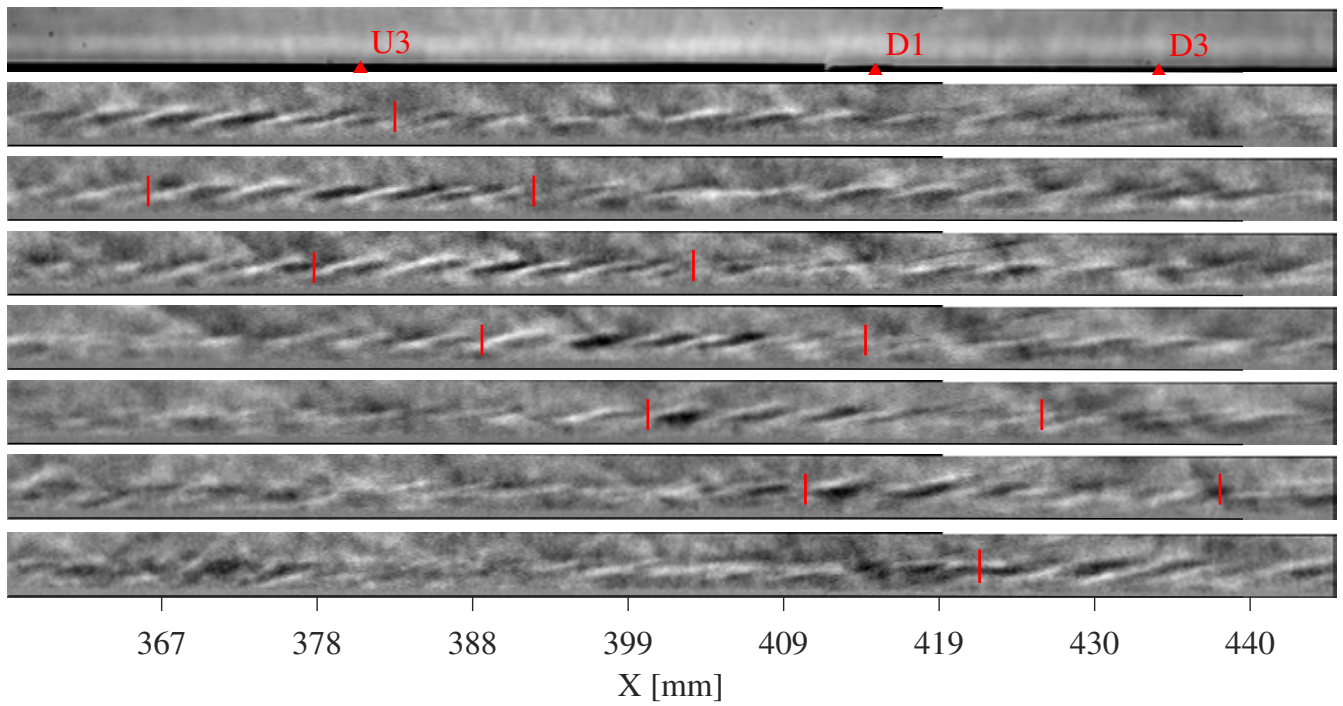


Figure 1: Reference-subtracted image sequence captured for the $+0^\circ$ configuration at condition Re45 with inter-image spacing of $9.4 \mu\text{s}$.

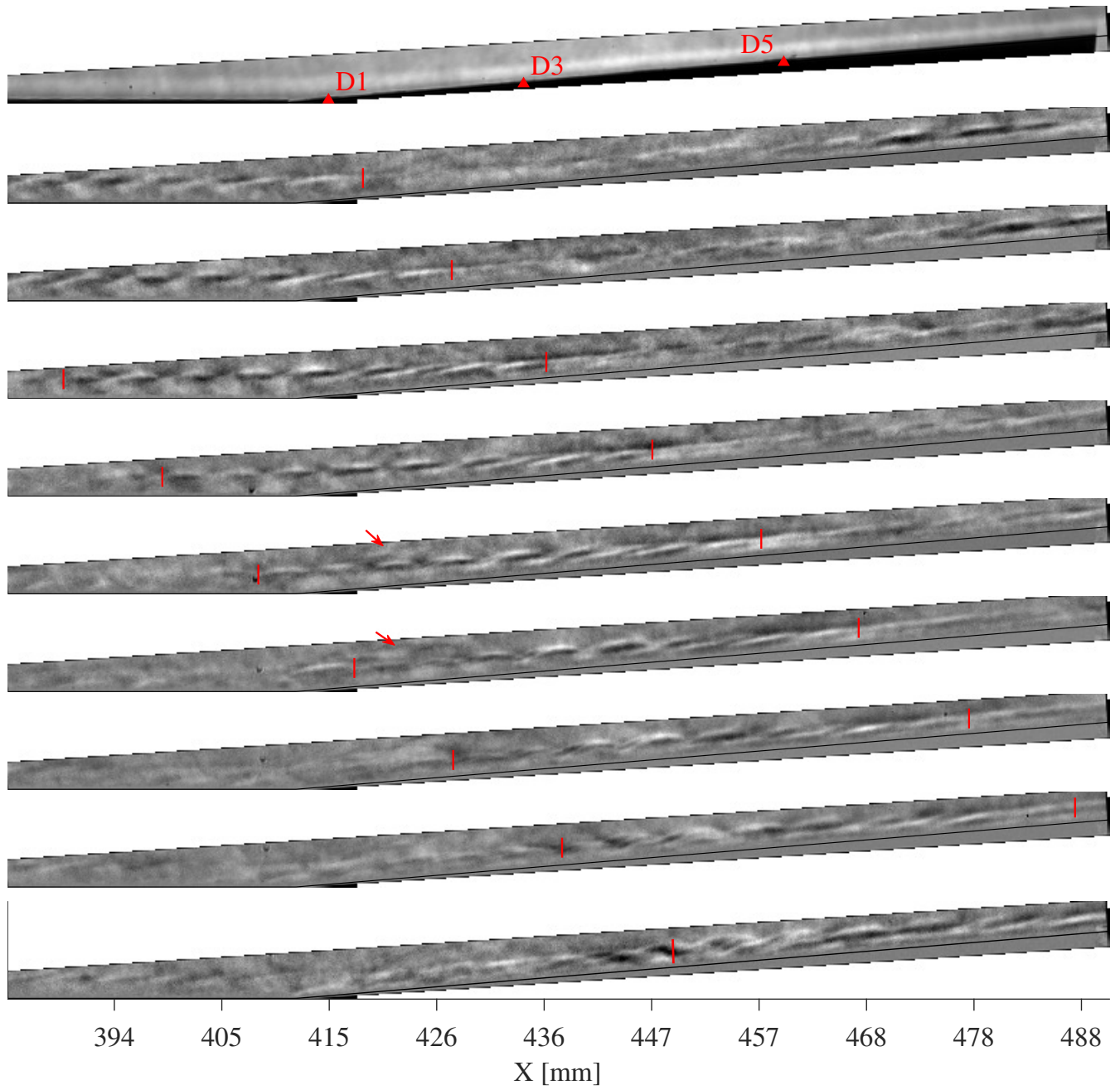


Figure 2: Reference-subtracted image sequence captured for the $+5^\circ$ configuration at condition Re33 with inter-image spacing of $8.8 \mu s$.

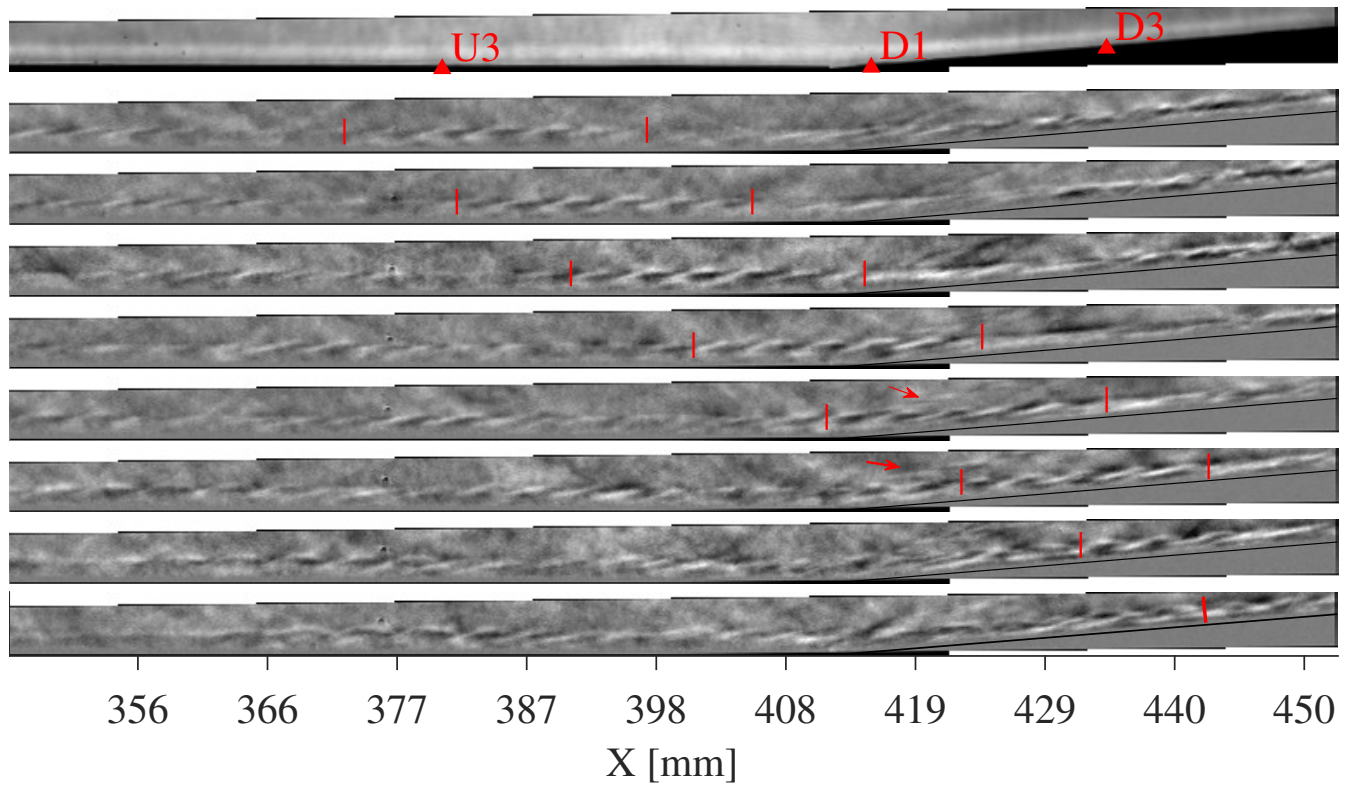


Figure 3: Reference-subtracted image sequence captured for the $+5^\circ$ configuration at condition Re52 with inter-image spacing of $8.8 \mu s$.

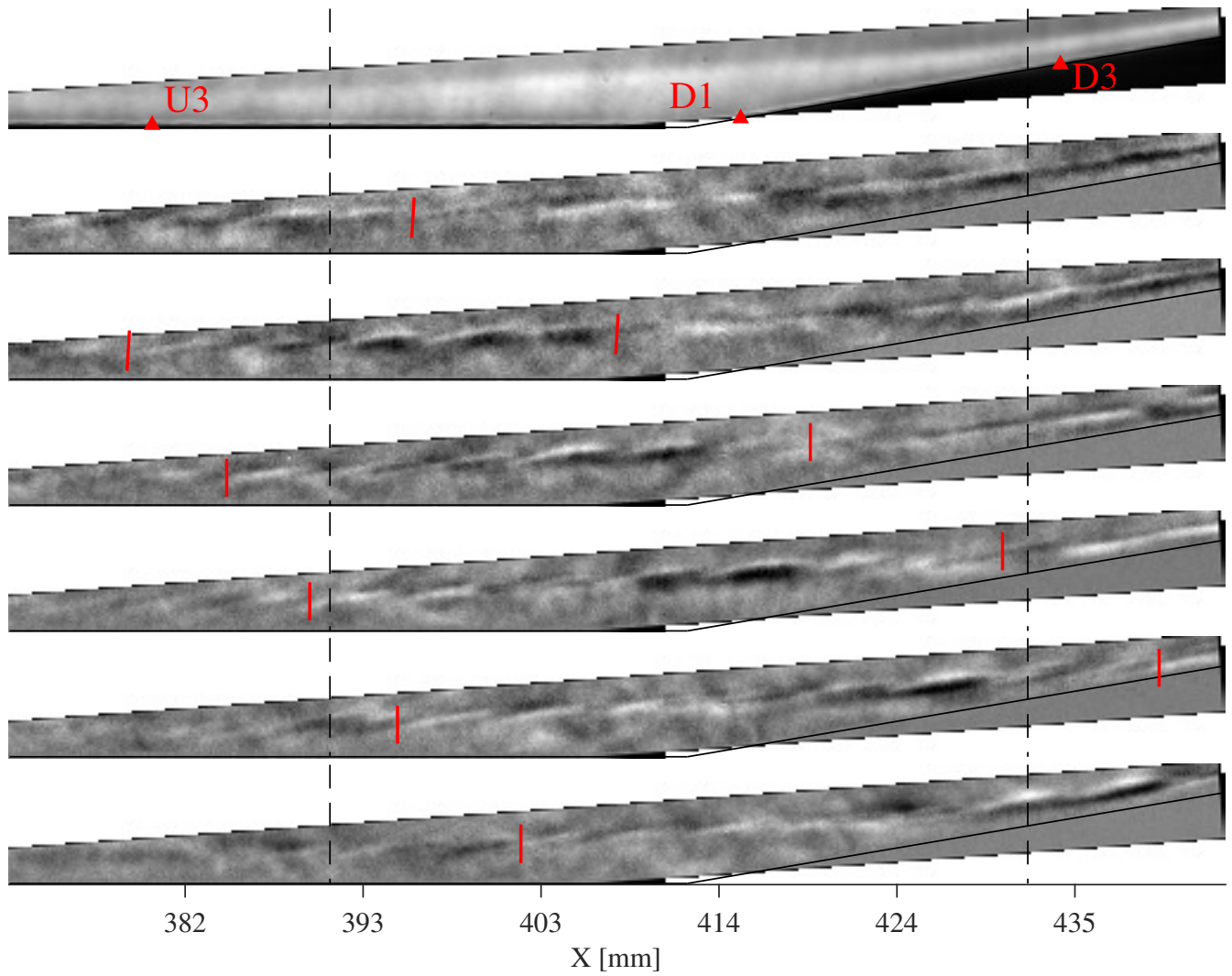


Figure 4: Reference-subtracted image sequence captured for the $+10^\circ$ flare at condition Re33 with inter-image spacing of $9.7 \mu\text{s}$.

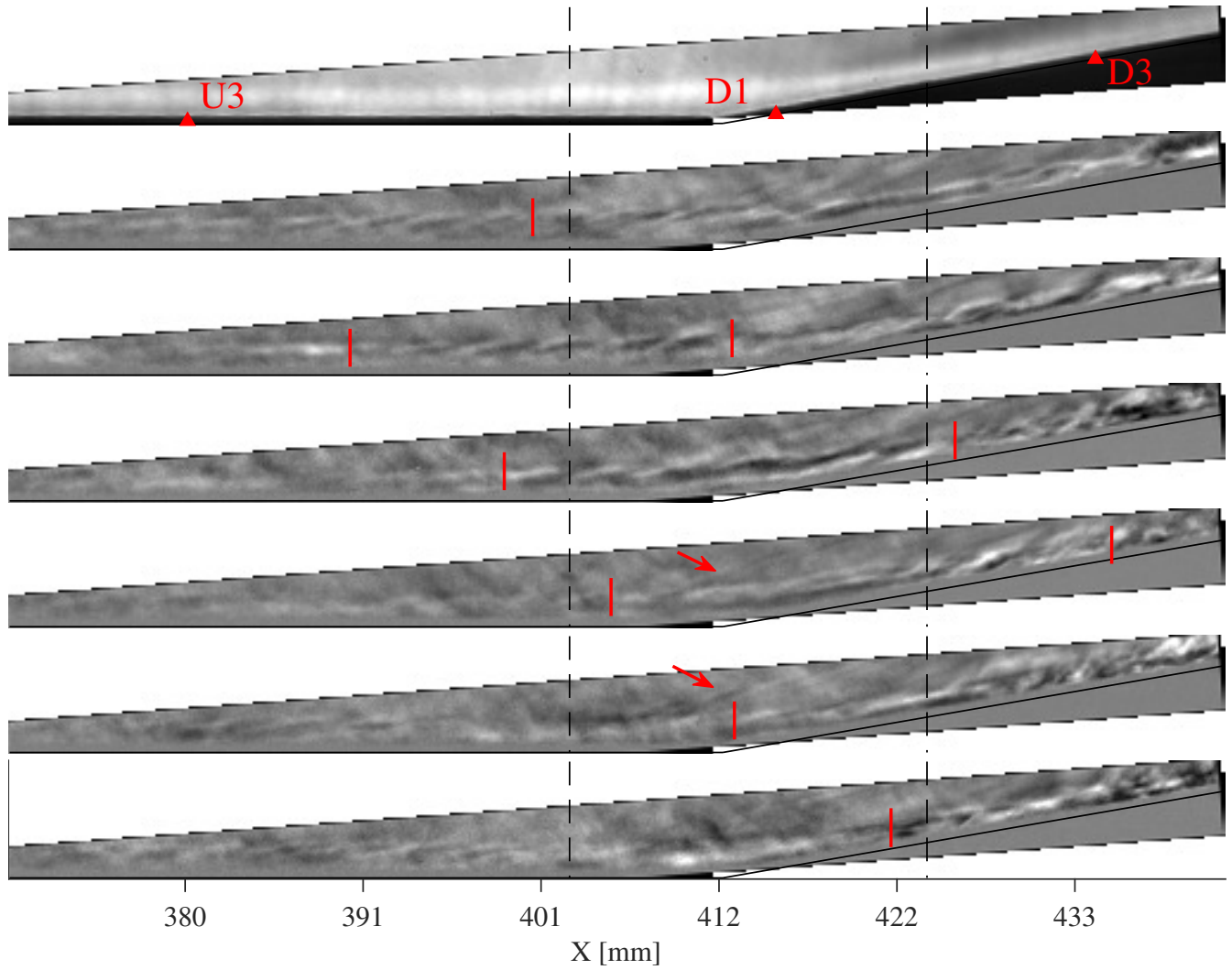


Figure 5: Reference-subtracted image sequence captured for the $+10^\circ$ flare at condition Re52 with inter-image spacing of $9.7 \mu\text{s}$.

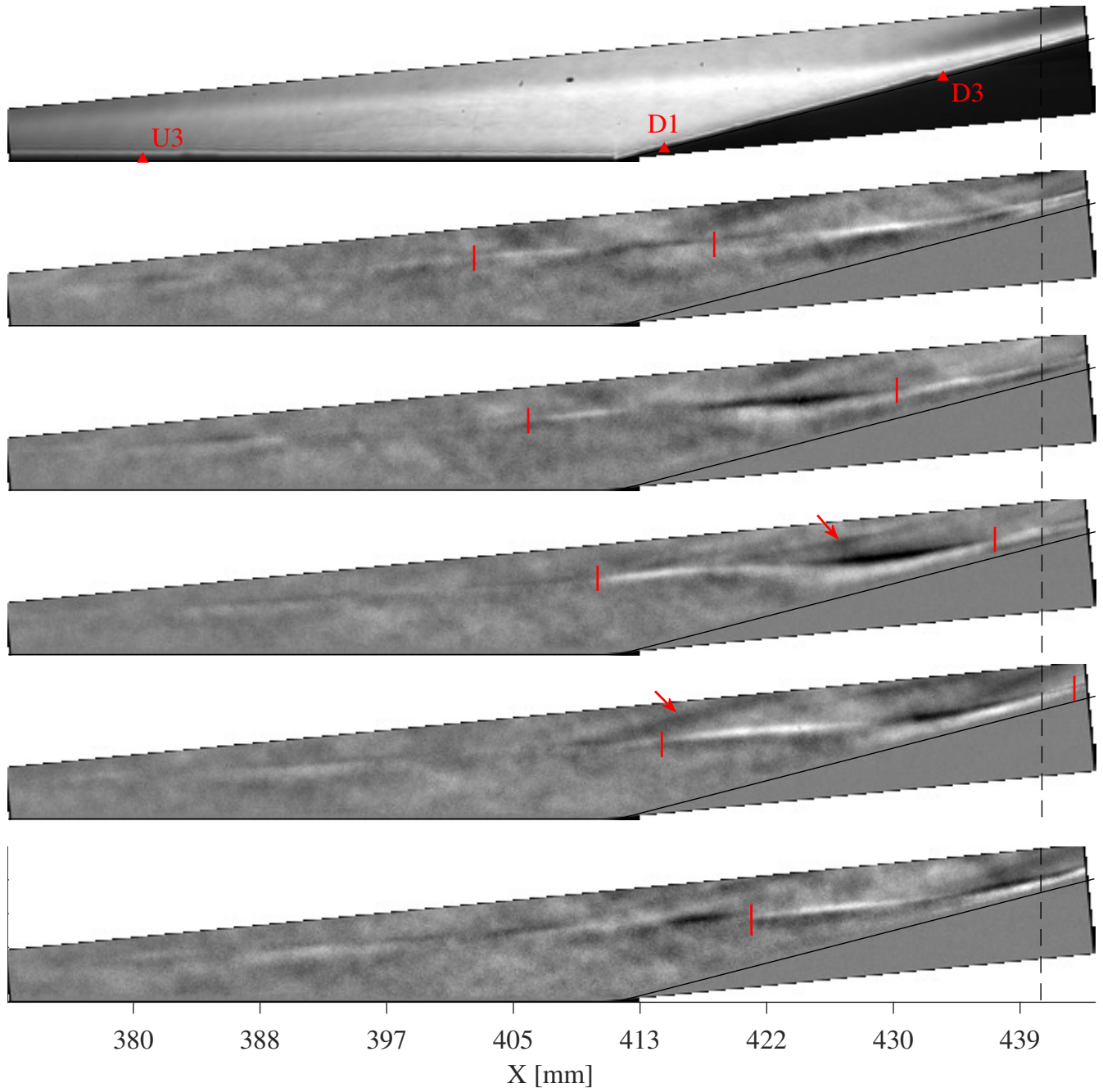


Figure 6: Reference-subtracted image sequence captured for the $+15^\circ$ configuration at condition Re33. Successive images are spaced by $6.8 \mu\text{s}$.

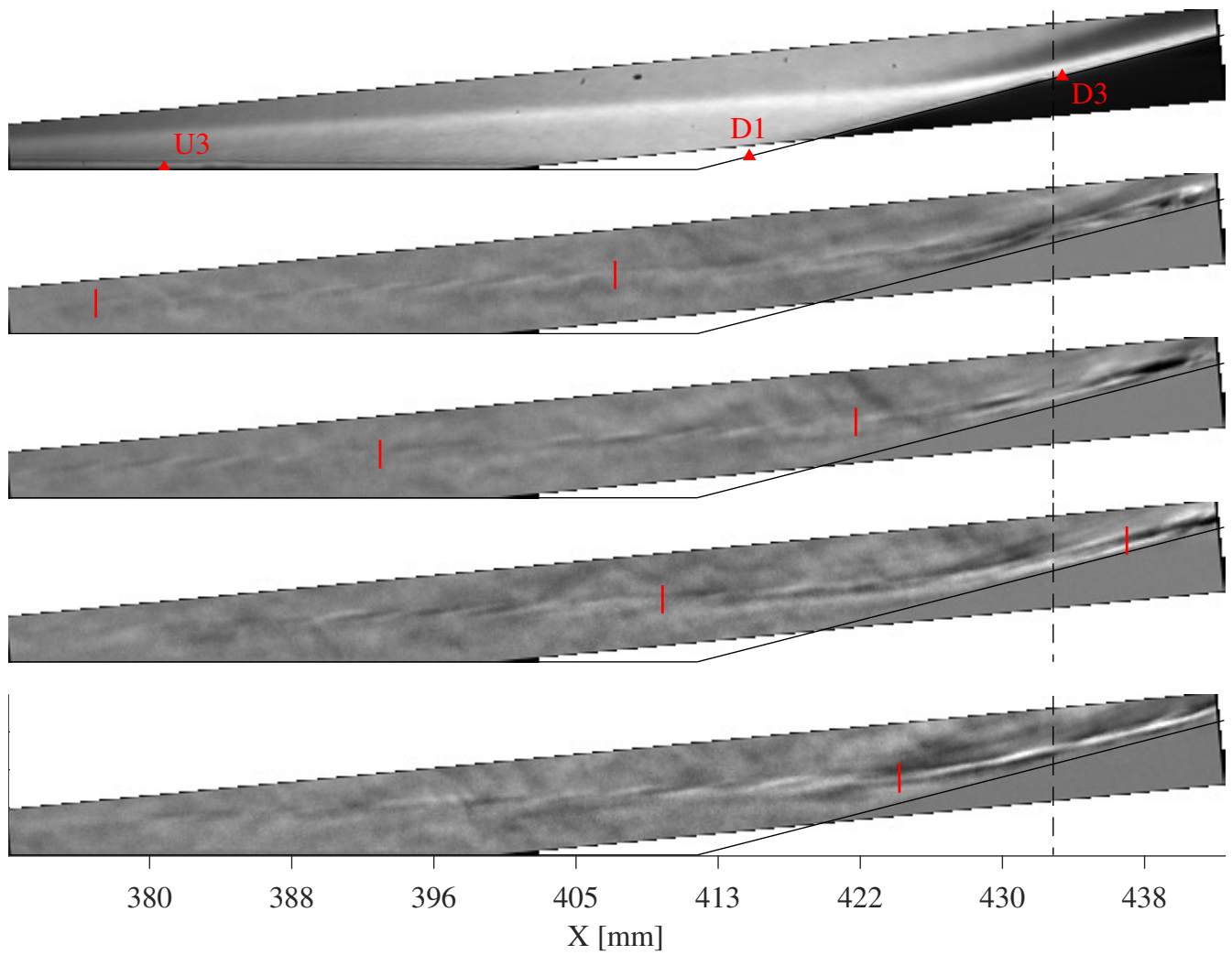


Figure 7: Reference-subtracted image sequence captured for the $+15^\circ$ configuration at condition Re45, showing an incoming second-mode wavepacket; $\Delta t = 9.1 \mu\text{s}$.

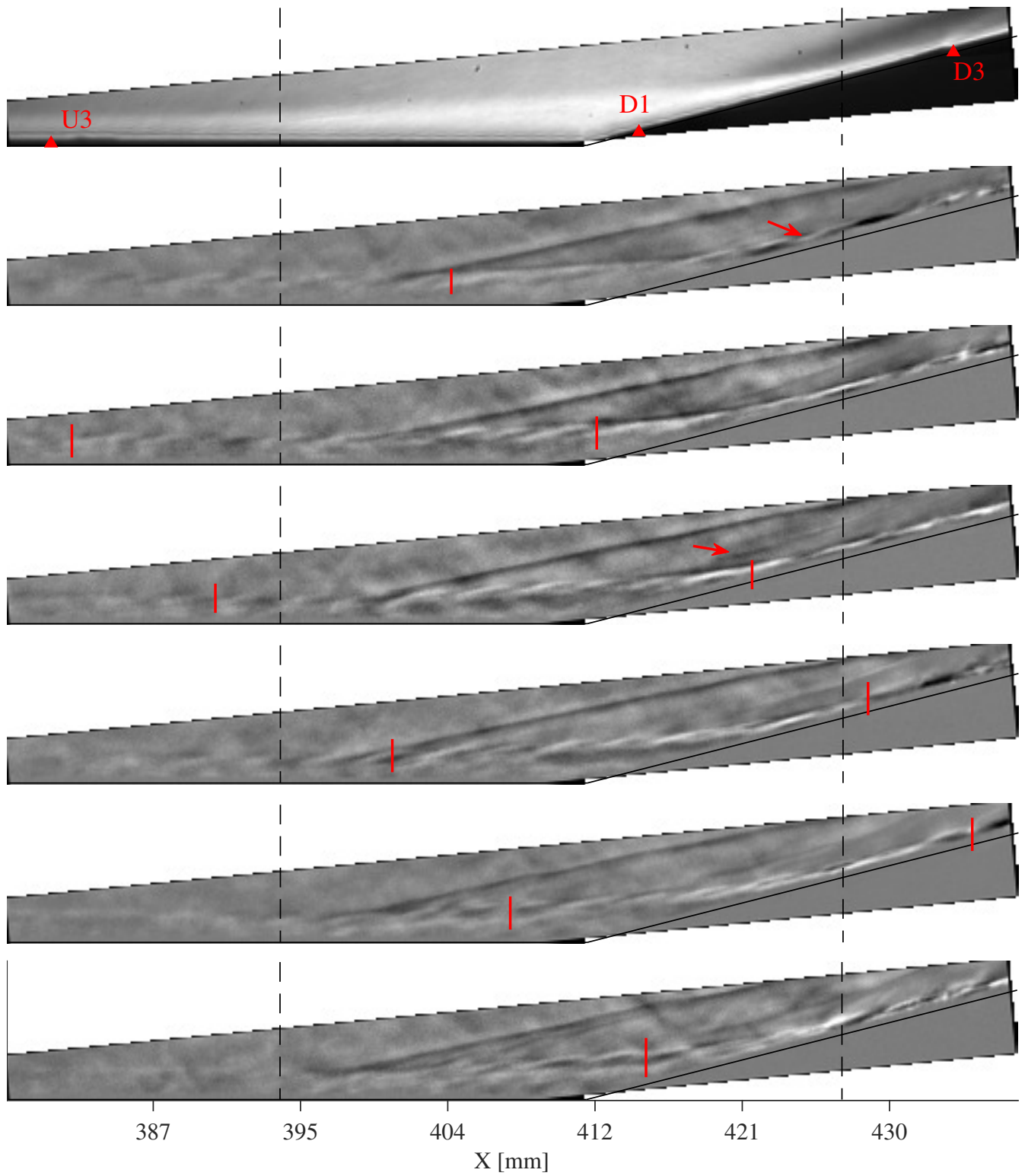


Figure 8: Reference-subtracted image sequence captured for the $+15^\circ$ configuration at condition Re52. Successive images are spaced by $8.2 \mu\text{s}$.