Turbulent Horizontal Convection at High Prandtl Numbers

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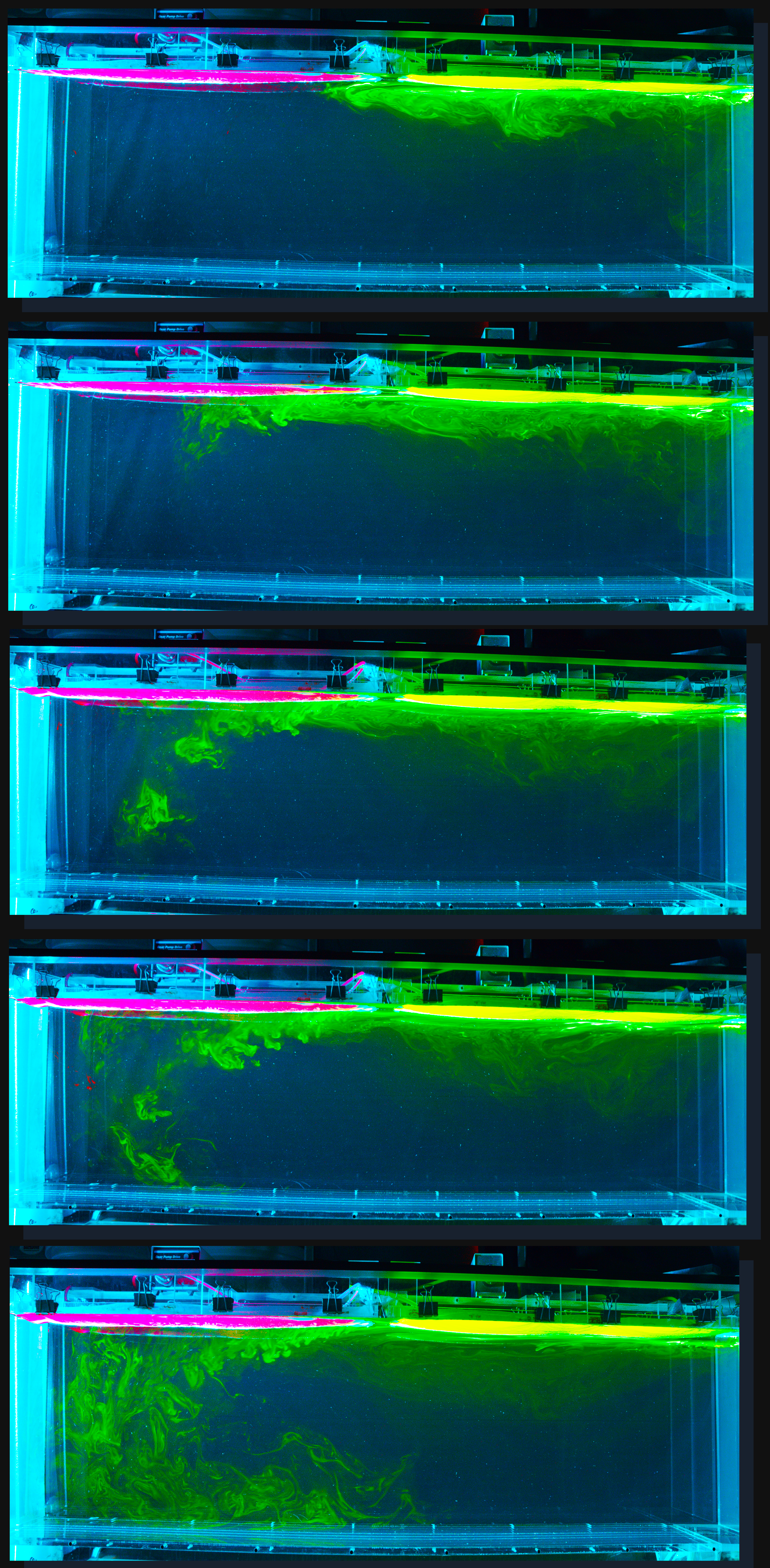
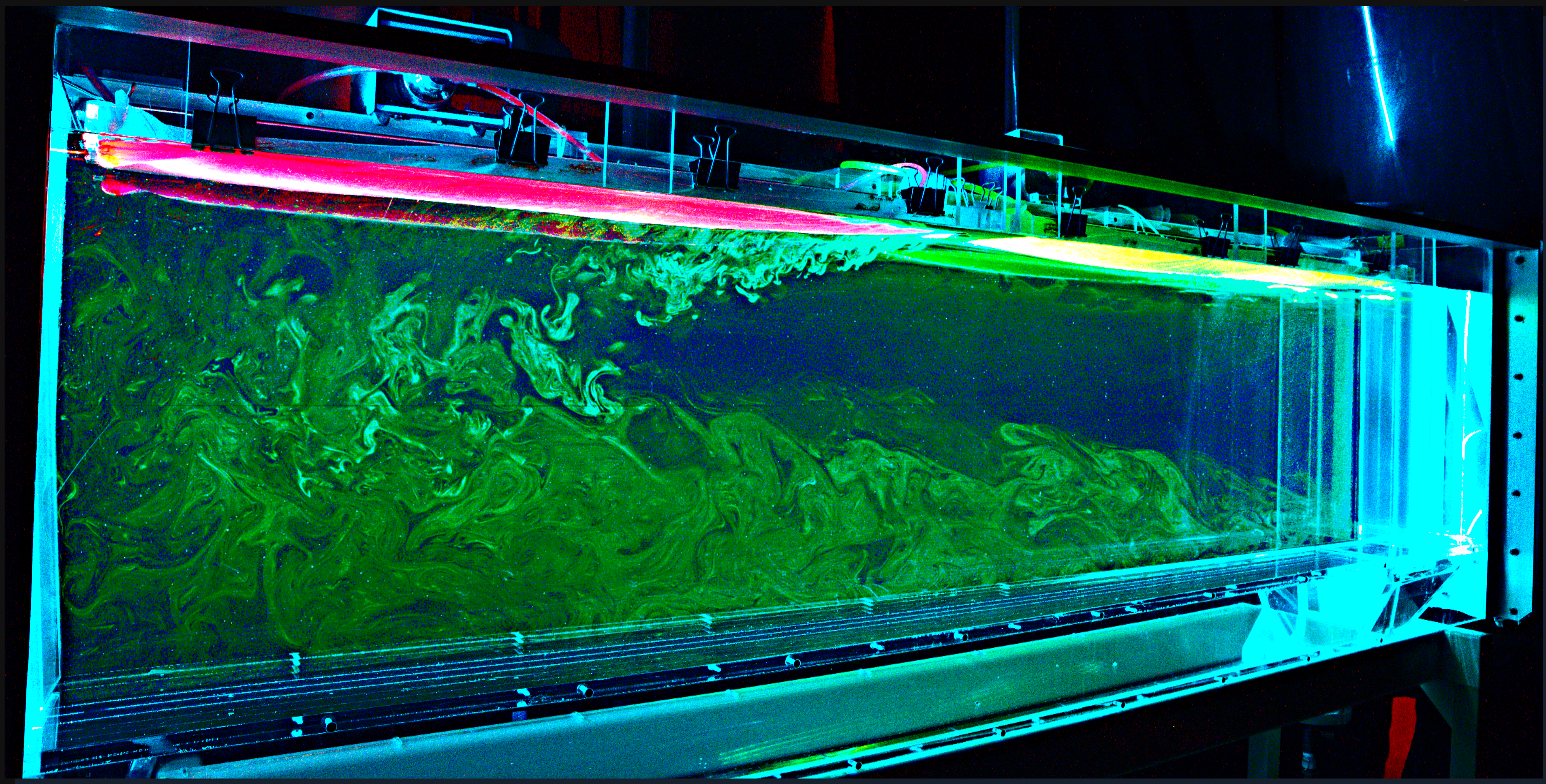
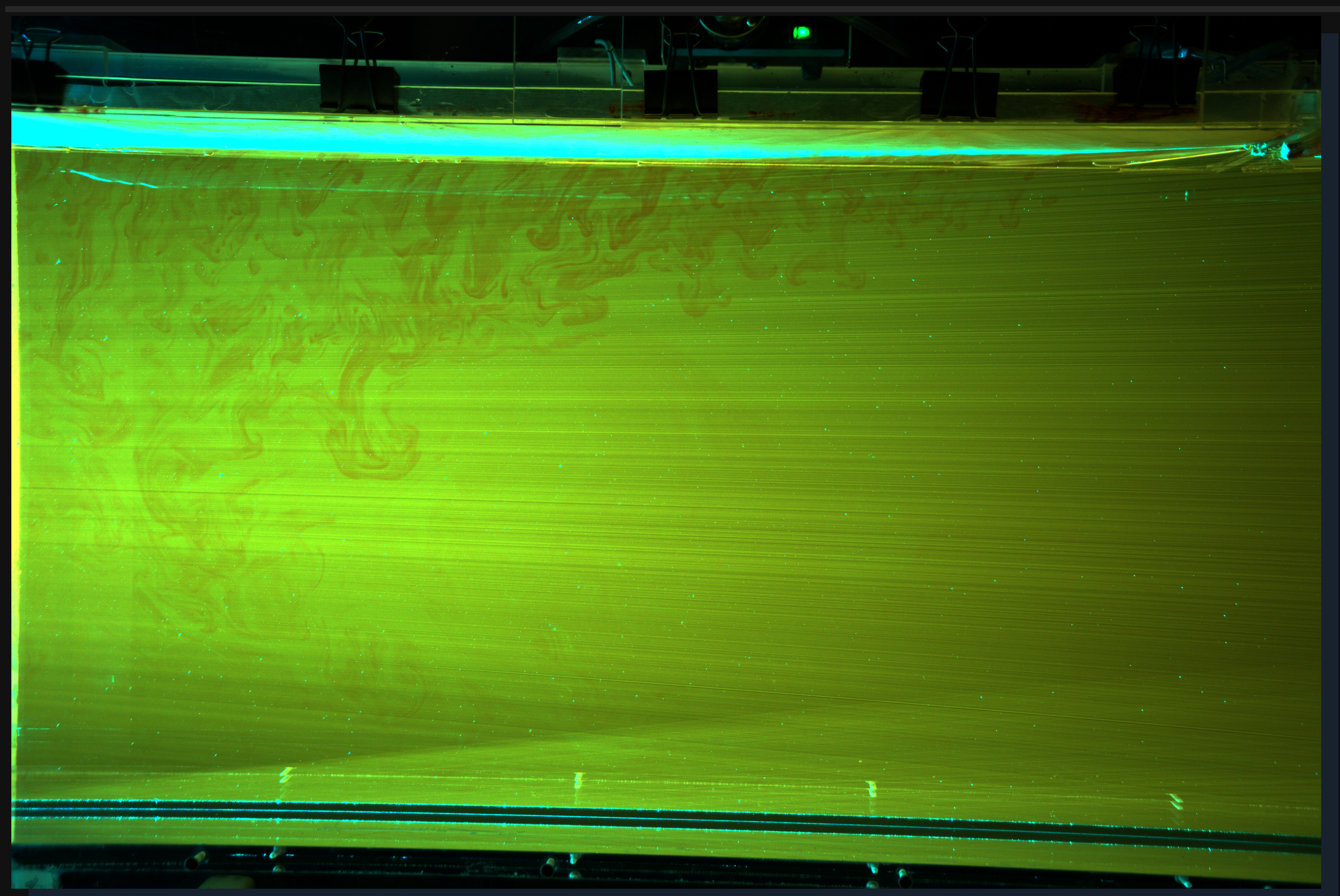


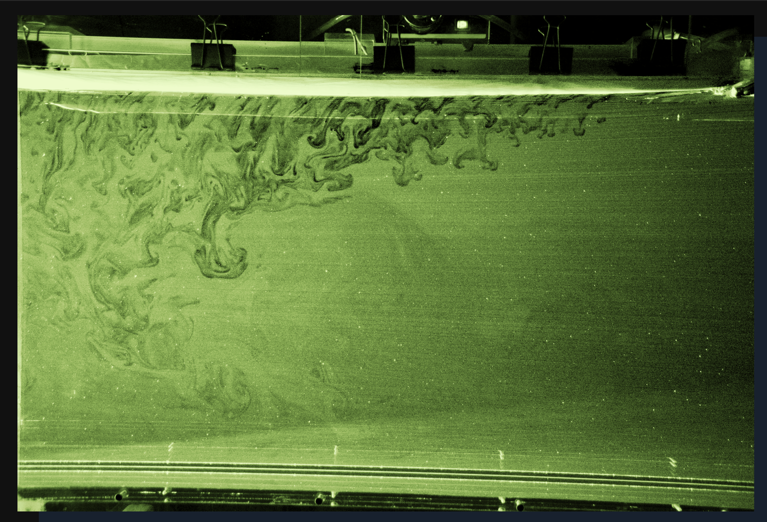


Horizontal convection is flow driven by a buoyancy gradient imposed along a horizontal boundary. It is a simple model to study the influence of heating, cooling and fresh water fluxes at the ocean surface around the meridional overturning circulation. In order to investigate the flow properties and energetics of horizontal convection at high Prandtl numbers, the flow is driven by the diffusion of salt in water across permeable membranes, stretched over the surface. The resulting experiments are examined for a Prandtl number of 700 and a Rayleight number of 10^{16} using dye visualization (top panels) and Dual Emission Laser Induced Fluorescence (DELIF) (bottom panels) [1].

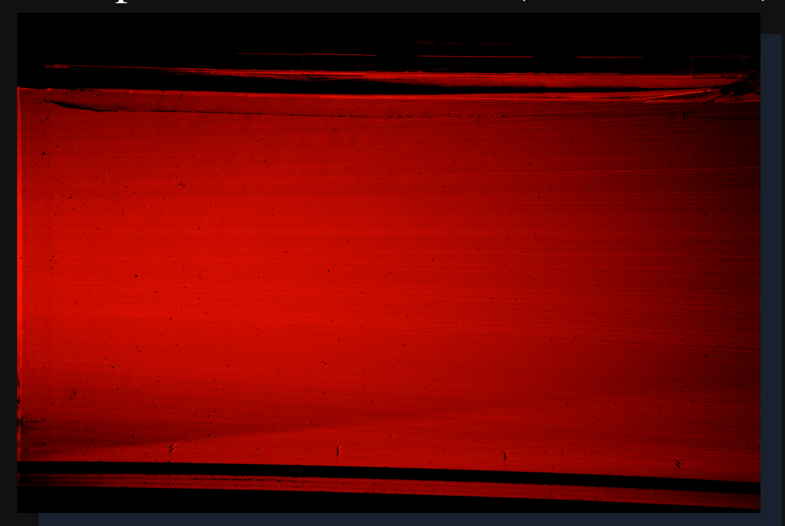
The top left and central panels show dye visualizations of the turbulent dynamics, the red side being salty (dyed with Rhodamine) and the green side fresh (dyed with Fluorescein). The flow is illuminated from the left side using a blue/green laser sheet from an Ar-Ion laser in the range 488-514 nm. The visualization is initiated with a few milliliters of fresh water dyed with fluorescein and injected near the surface, on the right side. At early times, the dye travels from the fresh side in a laminar and stratified layer towards the salty side where it sinks as a turbulent plume (left panel). The bottom of the tank is progressively filled with dyed/salty water which has mixed in the plume and represents a deep circulation where the flow utimately returns back to the surface in a broad and diffused upwelling (top panel).



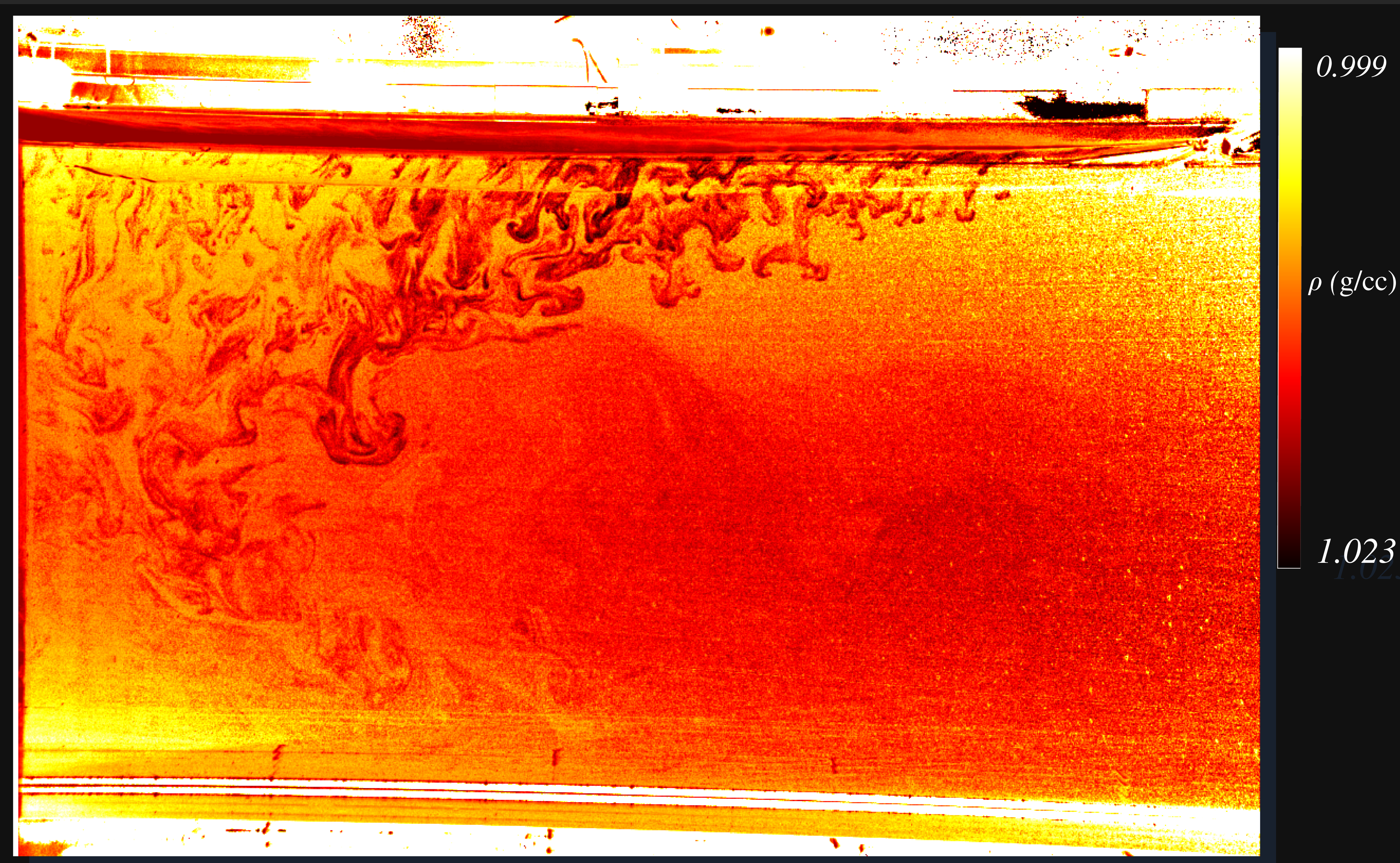
NaCl identified by adding $NaHSo_4$ (pH reducer) for LIF
RhodamineWT (pH insensitive) / Fluorescein (pH sensitive)



Band-pass filter at 530 nm (Fluorescein)



Band-pass filter at 580 nm (Rhodamine)



Density of the flow: $\rho \sim I_{Fluorescein}/I_{Rhodamine}$

The spatio-temporal diagnosis of the density of non homogeneous salt water is a difficult task, largely because the diffusion coefficient of organic dyes is one order of magnitude lower than the that of salt. Instead of using a single dye we introduce a second dye and a blend of sodium bisulfate with sodium chloride to decrease the pH of the salt water. The dyes are mixed homogeneously but the emission of the Fluoresecin decreases with decreasing pH while Rhodamine remains unaffected (see lower left panel). The ratio between the intensity of the two dies (central lower panels) is a visual for the density (lower right panel) .

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[1] Coppeta J. & Rogers C., Dual emission laser induced fluorescence for direct planar scalar behavior measurements, *Exp. in Fluids*, 25, 1–15 (1998)