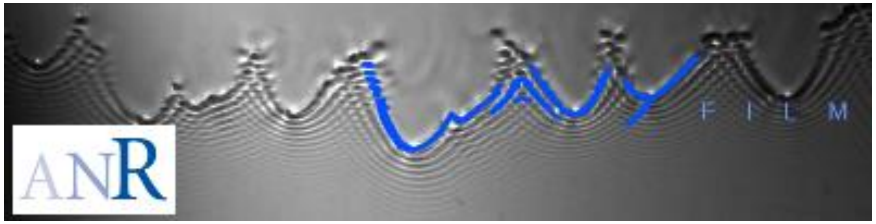
Flooding experiments in a narrow channel

FAST
Fluides, Automatique et Systèmes Thermiques

Yiqin Li , Sophie Mergui, Georg Dietze

Limsi

Gianluca Lavalle, Nicolas Grenier

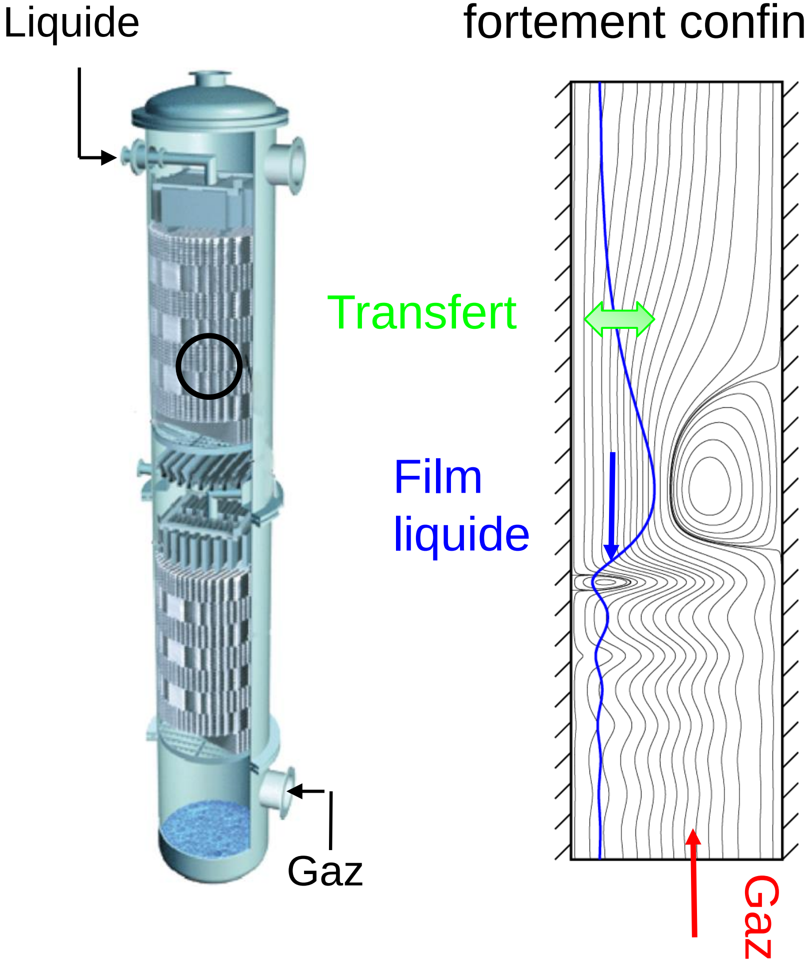


ANR WavyFilm

AIR LIQUIDE
cnrs
dépasser les frontières

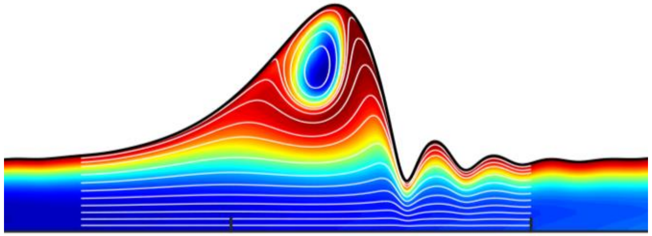
Contexte

Canal individuel fortement confiné



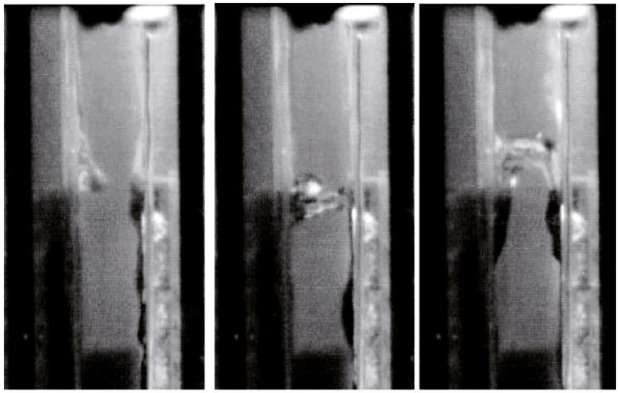
Dietze et Ruyer-Quil (JFM, 2013)

Intensification du transfert



Dietze 2018

Engorgement

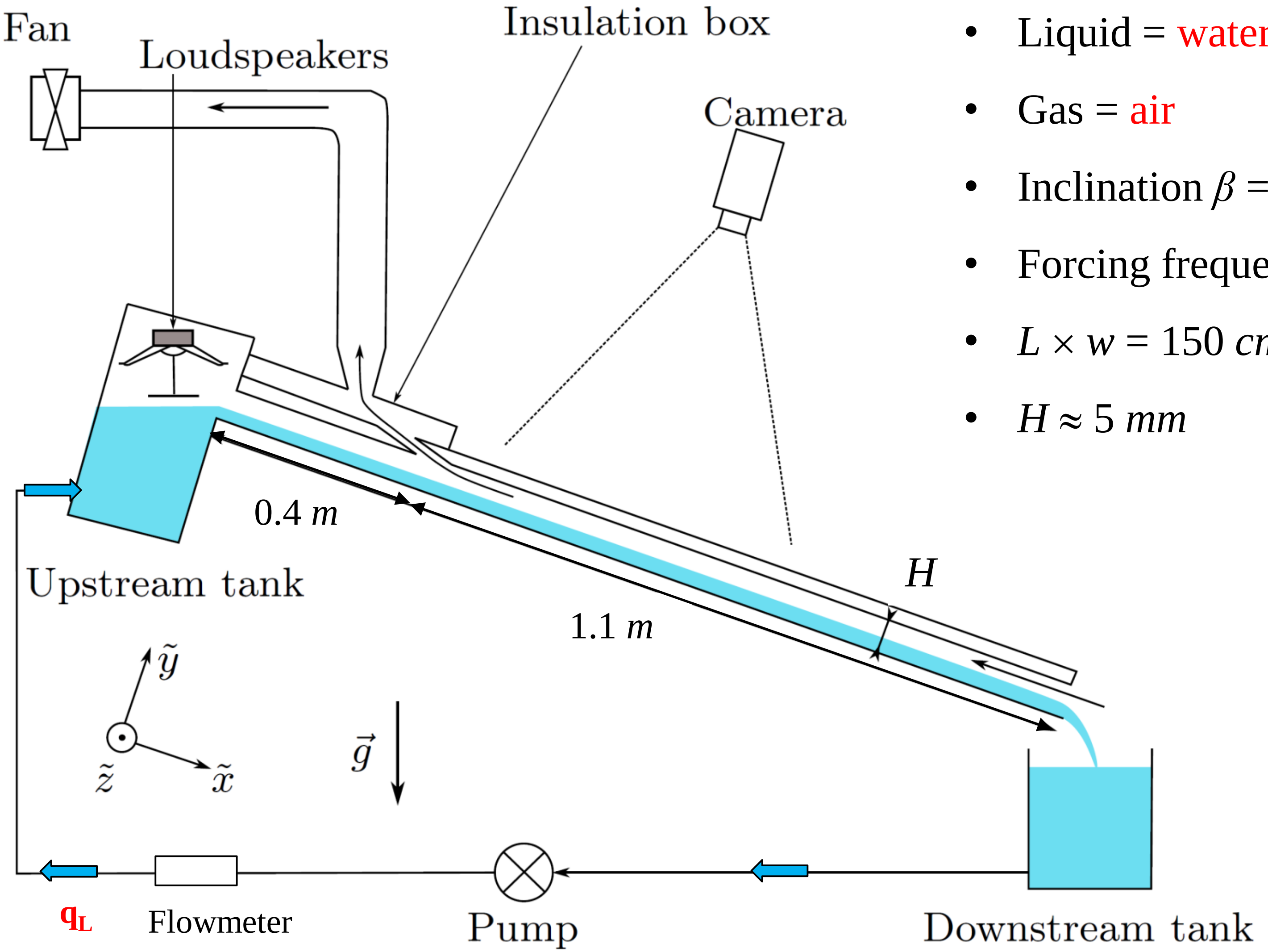


Vlachos et al. (IJMPF, 2001)

Identifier des régimes optimaux

- maximiser les transferts entre gaz et liquide
- éviter l’engorgement

Experimental set-up



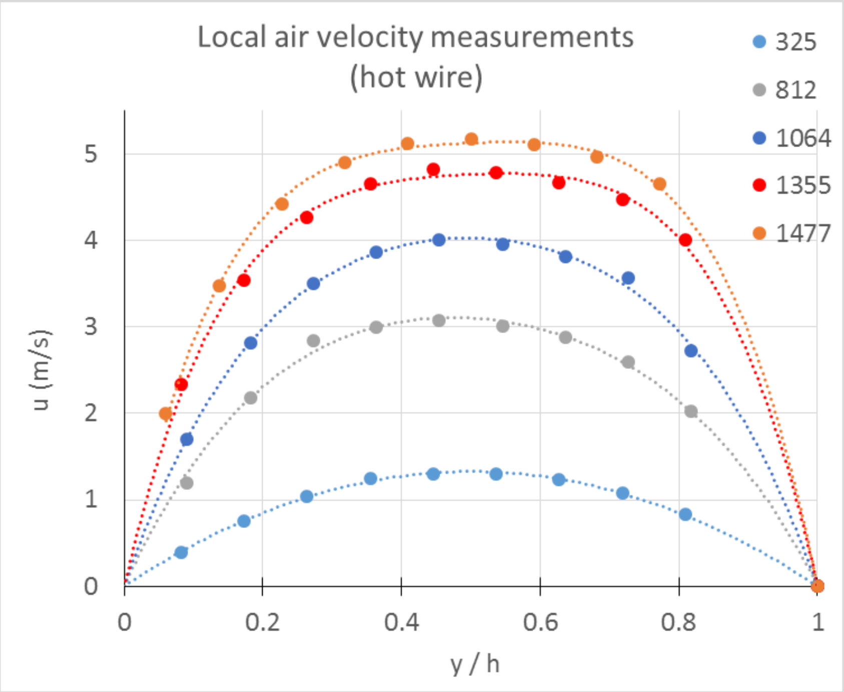
- Liquid = water
- Gas = air
- Inclination $\beta = 0$ - 20°
- Forcing frequency $f = 1 – 10\ Hz$
- $L \times w = 150\ cm \times 27\ cm$
- $H \approx 5\ mm$

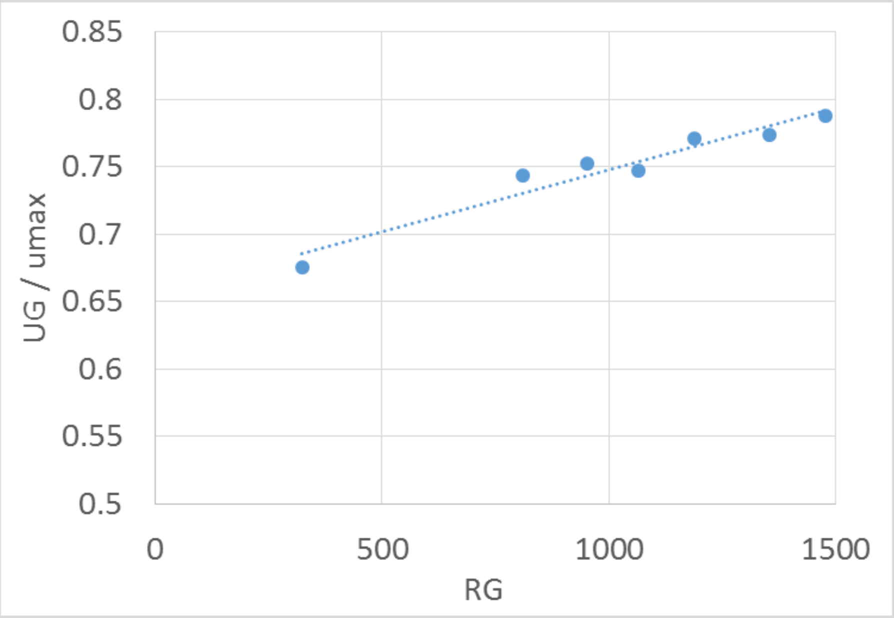
Experimental parameters

β	3° and 4.9°
R_L	22 - 65
$f\,(Hz)$	2.2 - 3
R_G	0 - 1500

➢ $$R_L = \frac{q_L}{\gamma_L}$$

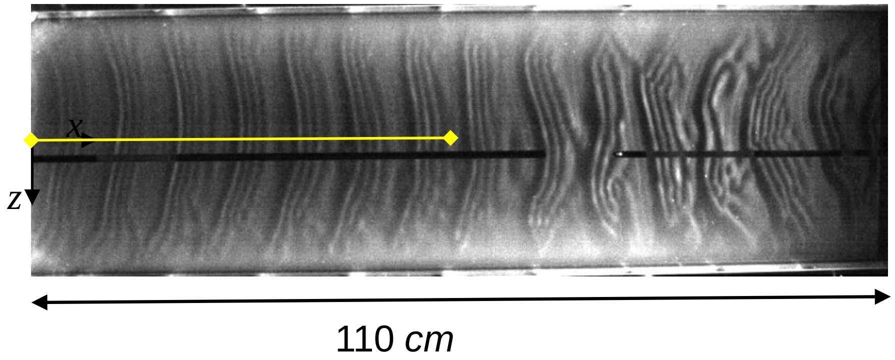
➢ $$R_G = \frac{U_G^0\, H}{\gamma_G}$$



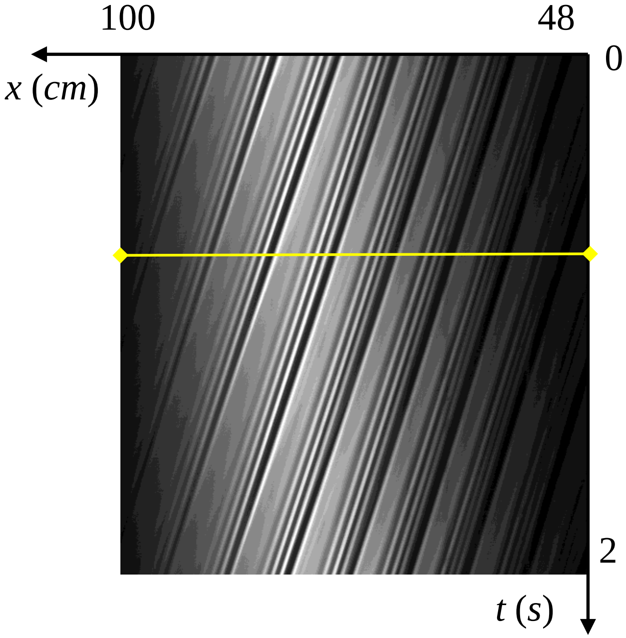


Experimental set-up

- Visualisation: 2D camera

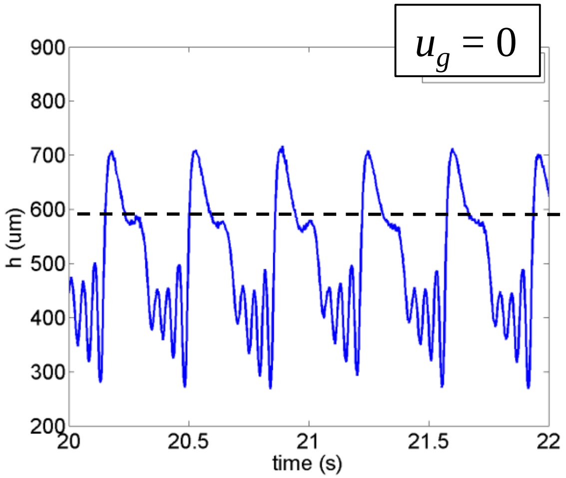


- Wave celerity: linear CCD camera



- Film thickness: One-point temporal measurement Confocal Chromatic Imaging (CCI)

temporal resolution: up to 2 *kHz*
accuracy: 300 *nm*



$$h_m^0 = h_m(u_g = 0)$$

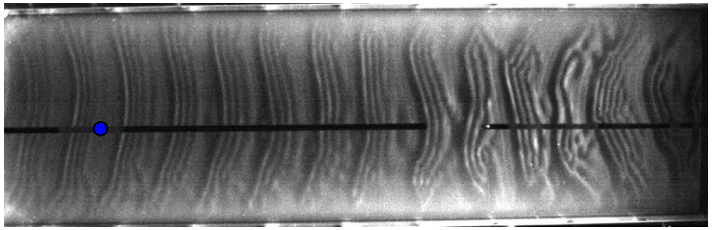
Relative confinement

$$\boxed{\eta_m^0 = \frac{H}{h_m^0}}$$

Results: effect of the counter-current air flow on solitary waves

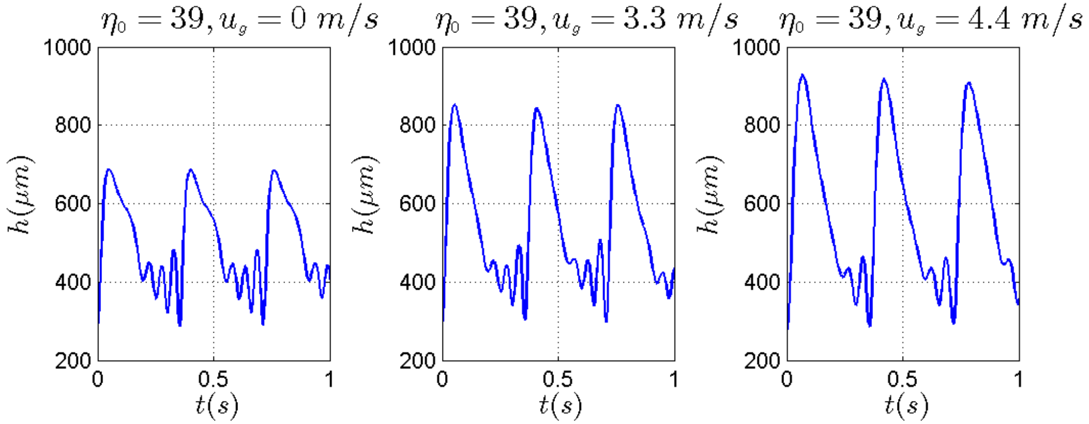
β	4.9°
R_L	$35 = 2.2\,R_c$
f (*Hz*)	2.8

$x = 60\ cm$



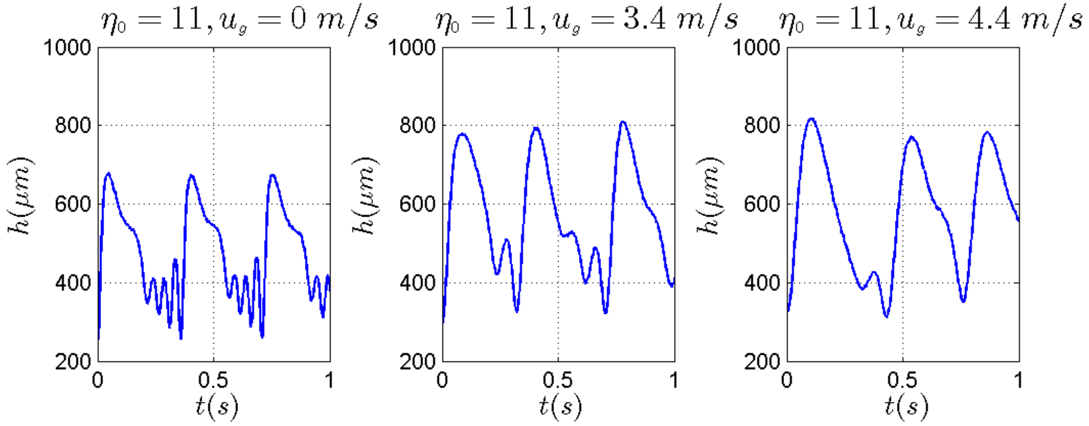
Kofman's exp. (*H* = 19 *mm*)

$\boxed{\eta_m^0 = 39}$

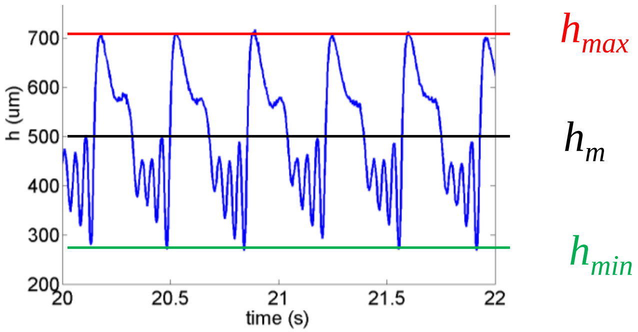


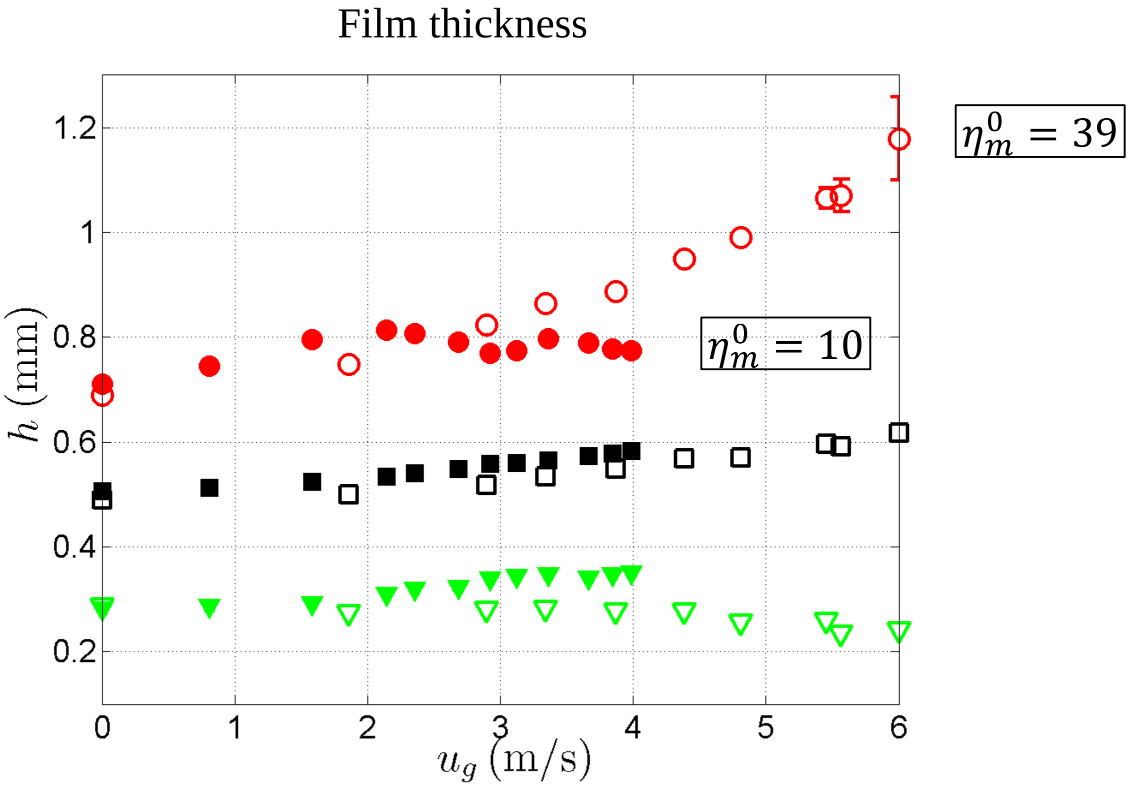
Current exp. (*H* = 5.2 *mm*)

$\boxed{\eta_m^0 = 11}$



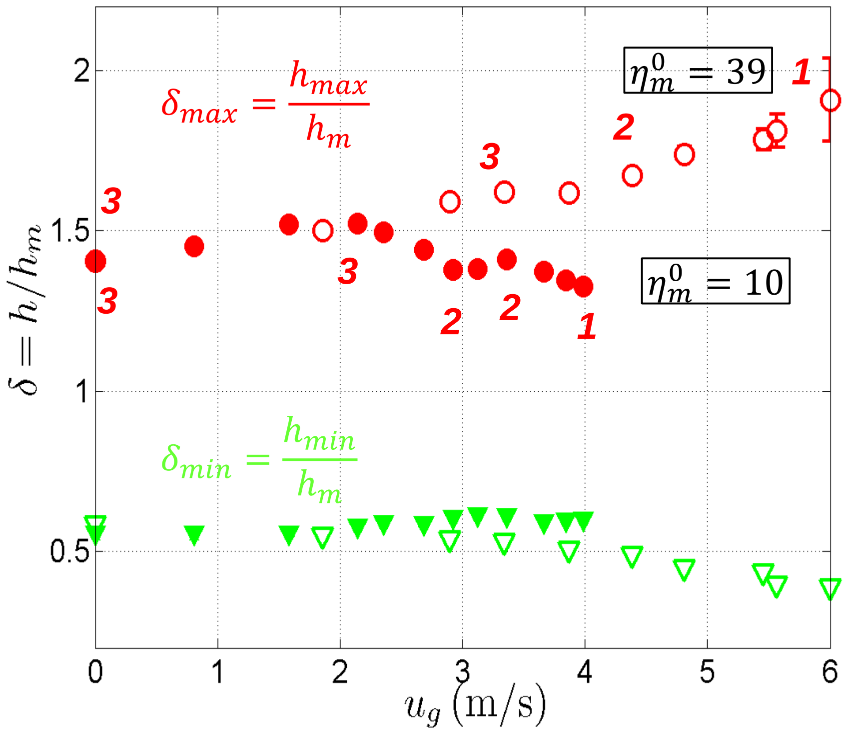
Results: effect of the counter-current air flow on solitary waves



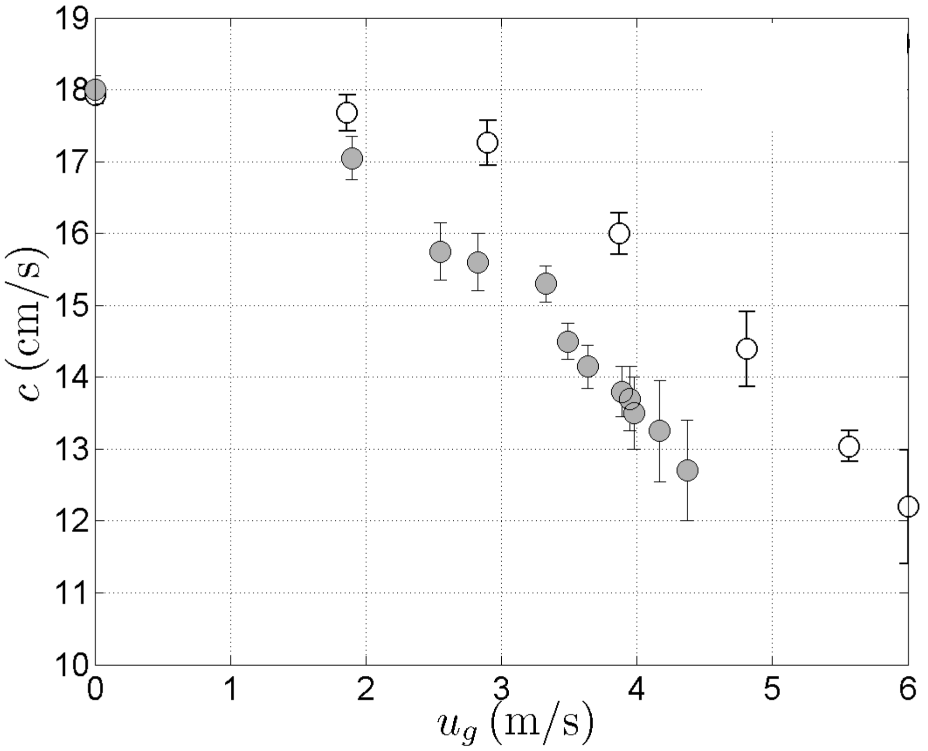


Results: effect of the counter-current air flow on solitary waves

Relative film thickness



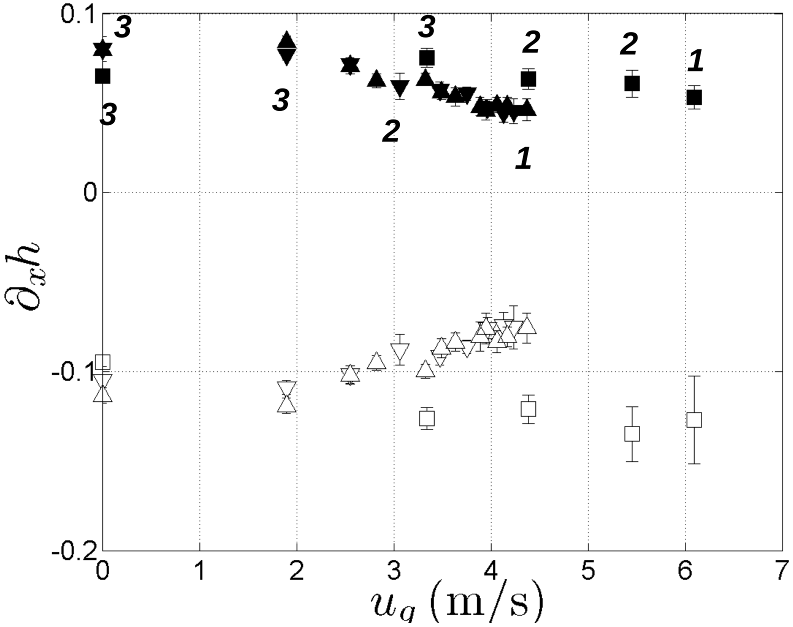
Wave celerity



Effect of the gas: weak confinement ⇒ destabilizing

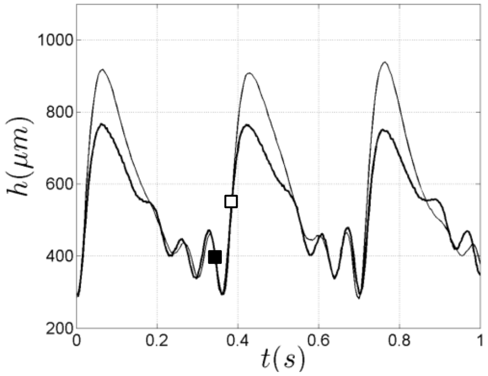
strong confinement ⇒ stabilizing

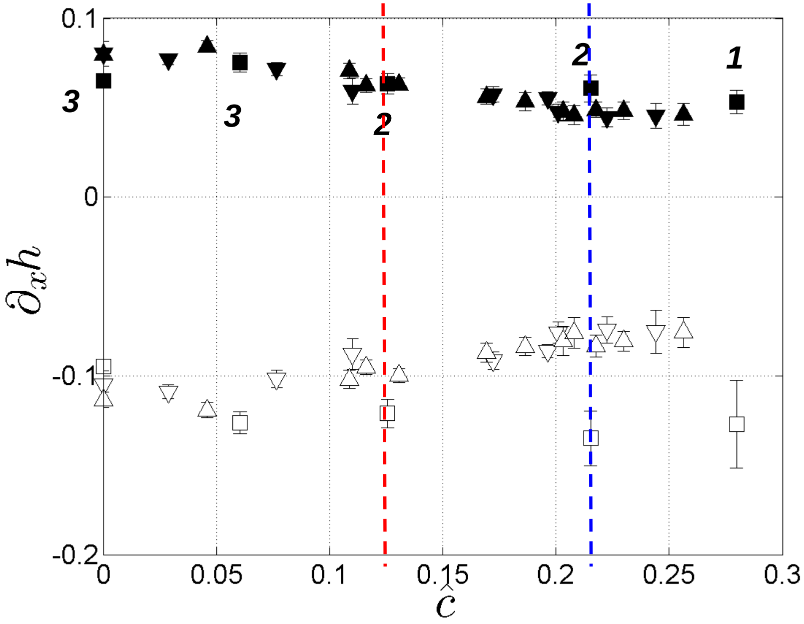
Results: effect of the counter-current air flow on solitary waves



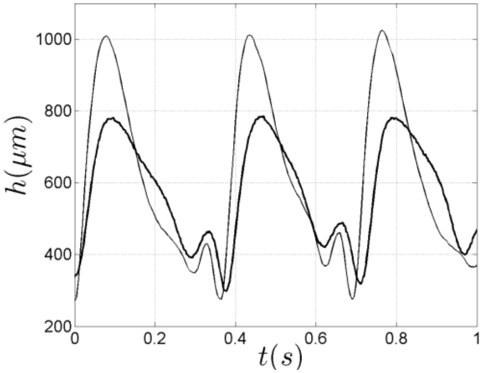
$$\hat{c} = \frac{c_0 - c}{c_N} \qquad c_N = \frac{g h_N^2 sin\beta}{\nu}$$

$\hat{c} = 0.12$





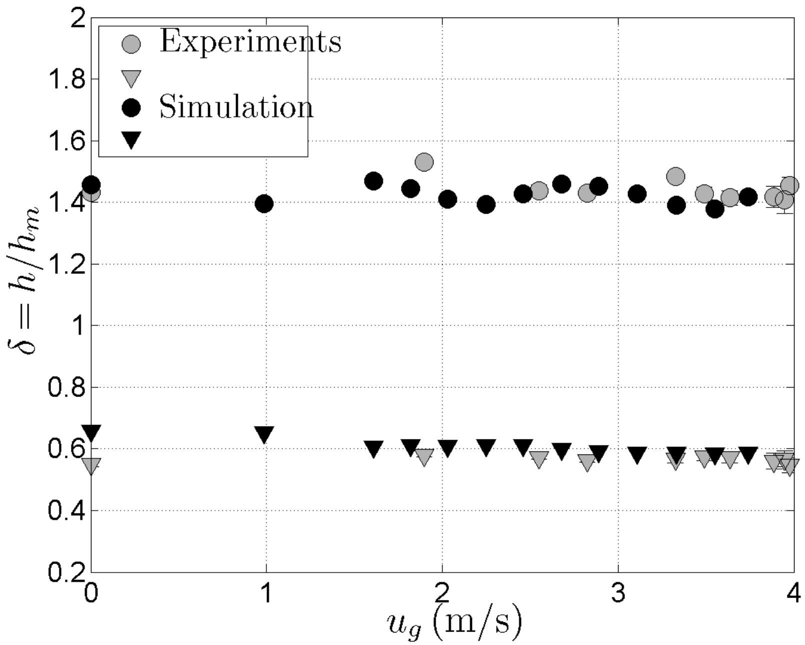
$\hat{c} = 0.21$



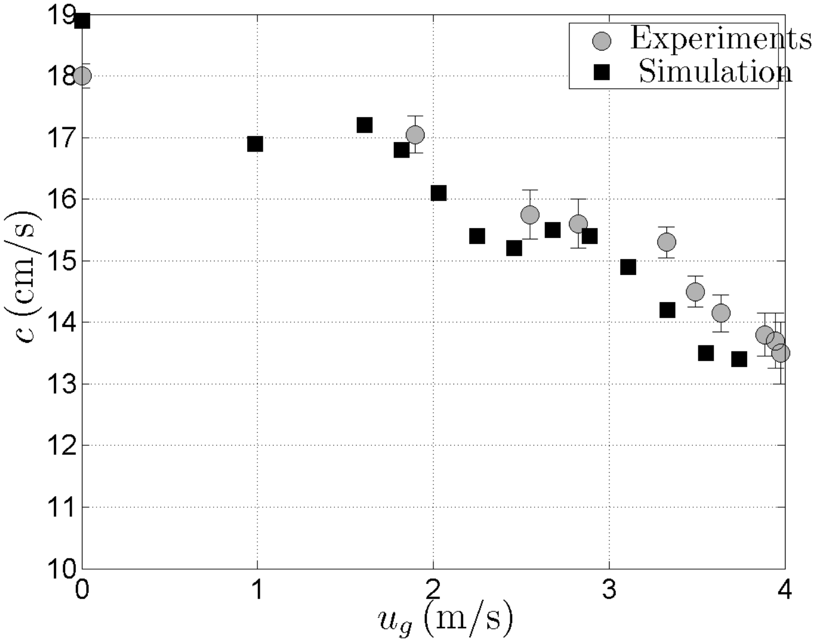
Results: Comparison with direct numerical simulations - DassFlow Code

$$\boxed{\eta_m^0 = 11}$$

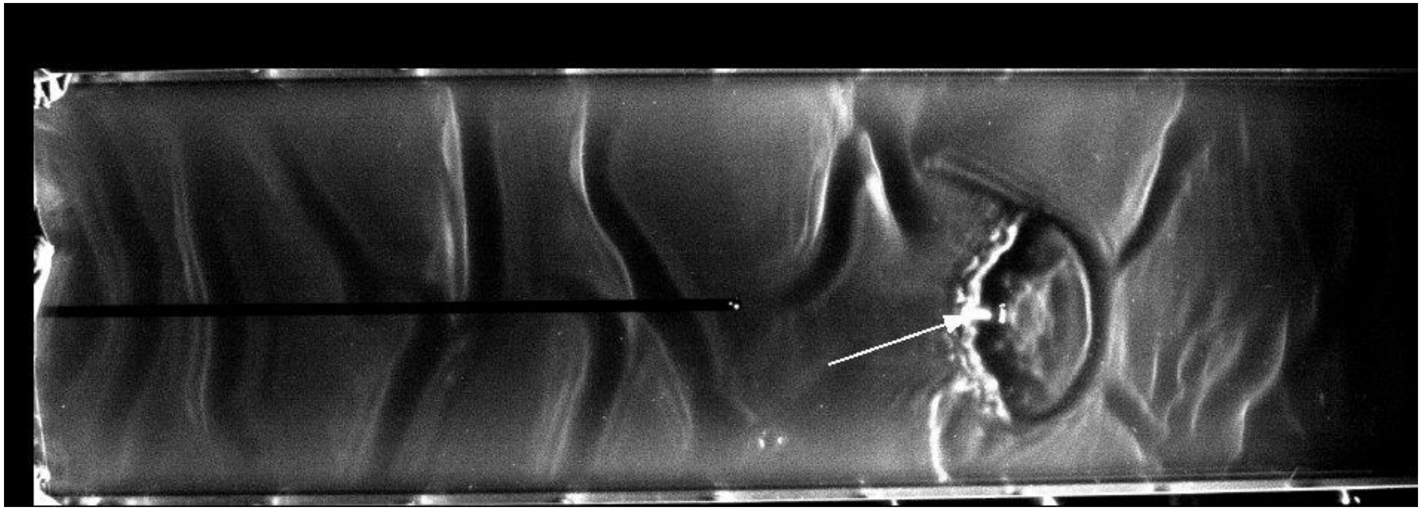
Relative film thickness

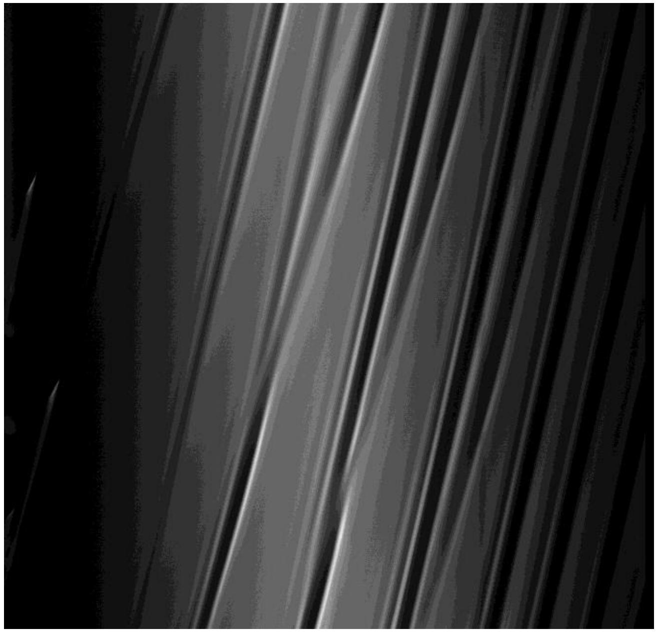


Wave celerity

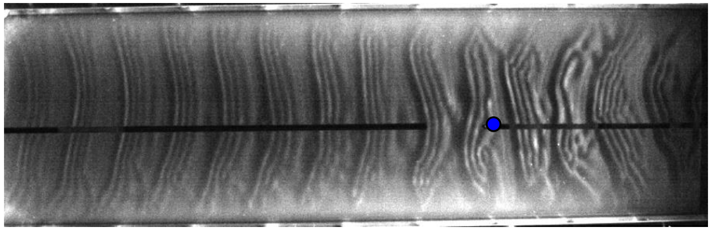


Flooding



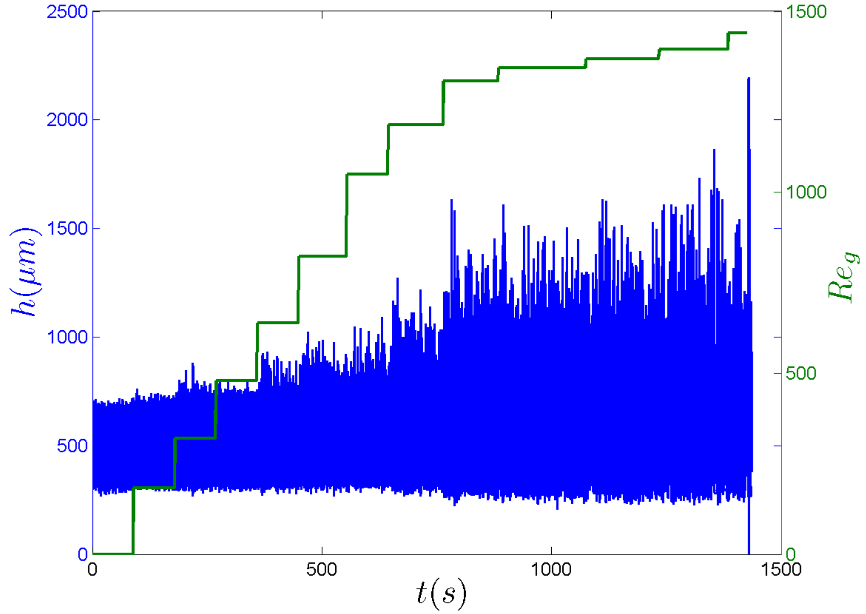


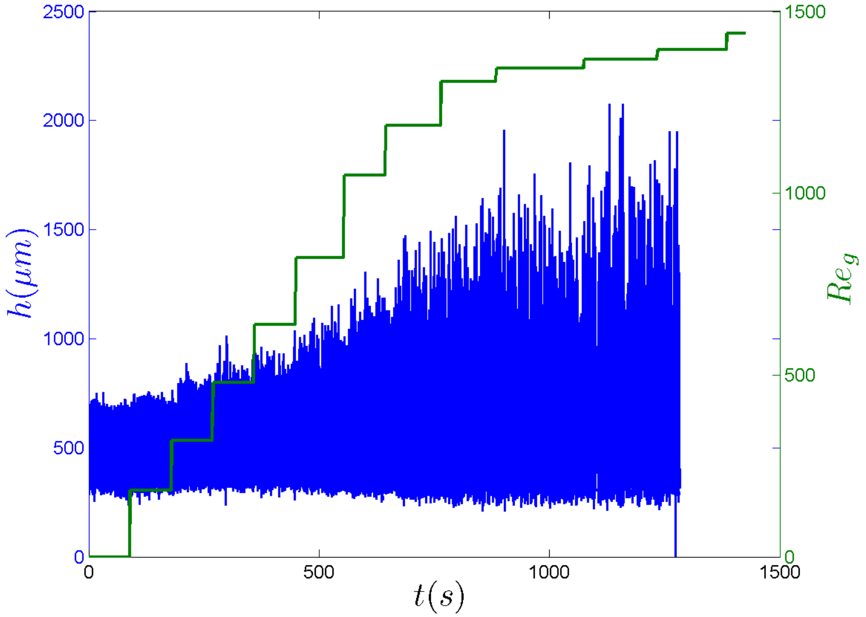
Flooding



$f = 2.8\ Hz$

without excitation





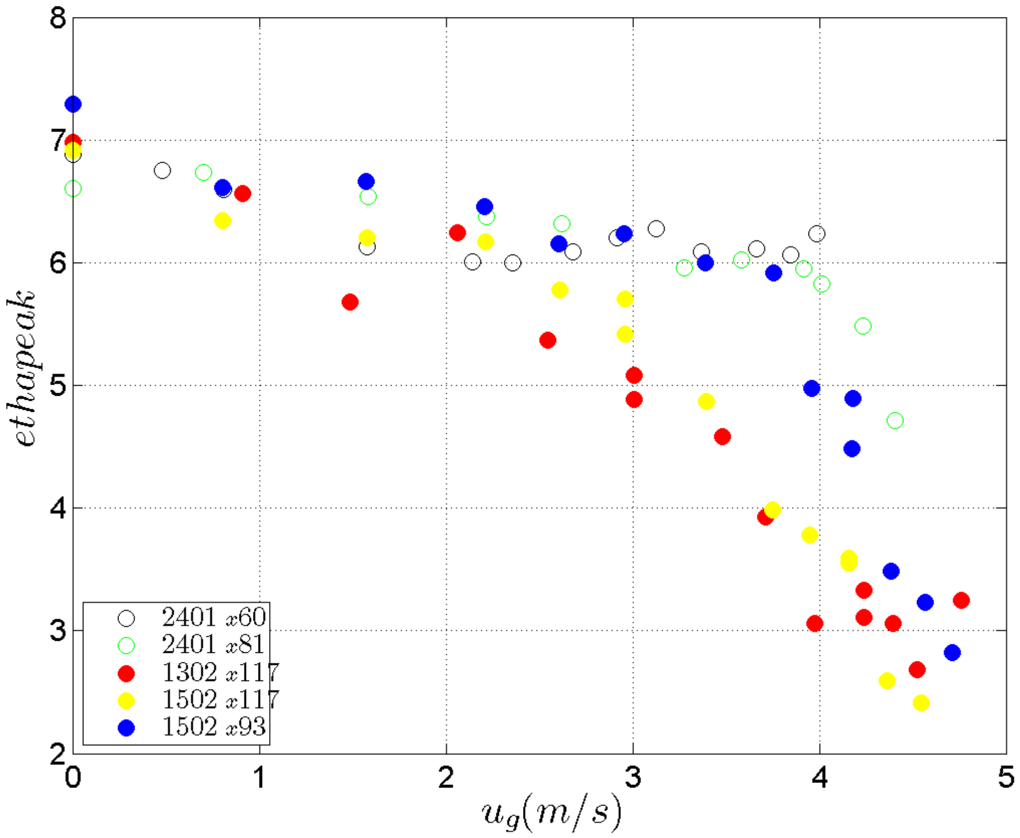
Flooding location: x = 105 cm

Flooding location: x = 95 cm

$\eta_{peak} = H/h_{peak} = 2.9$

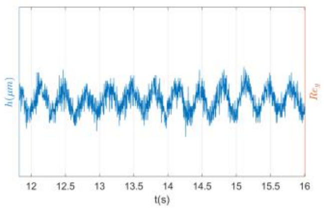
$\eta_{peak} = H/h_{peak} = 2.8$

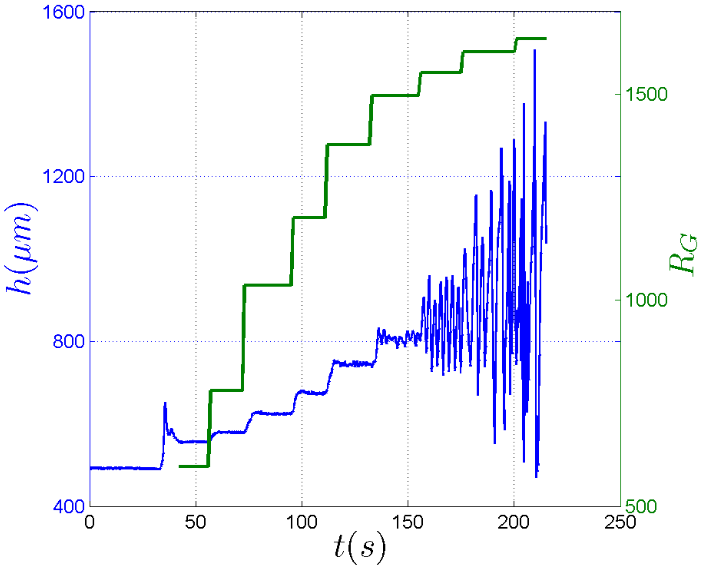
$\eta_{peak} = H/h_{peak}$



Flooding

$\beta = 3°$, $R_L = 17.9 = 1.13\ Rc$
$f = 3\ Hz$
$x = 72\ cm$

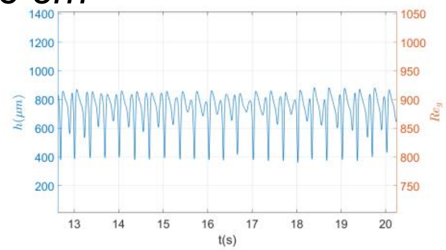


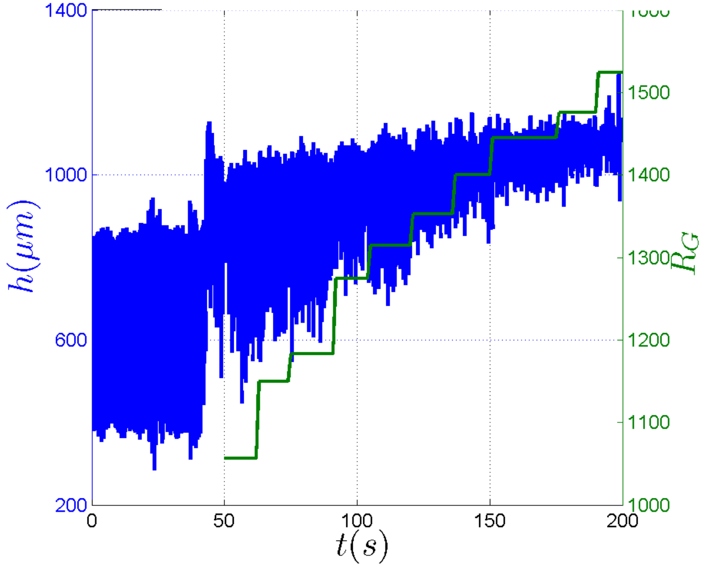


Flooding location: x = 60 cm

$\eta_{peak} = H/h_{peak} = 3.3$

$\beta = 3°$, $R_L = 61.9 = 3.9\ Rc$
$f = 3\ Hz$
$x = 90\ cm$





Flooding location: x = 110 cm

$\eta_{peak} = H/h_{peak} = 3.9$

Perspectives

- Augmenter le confinement en prenant un fluide plus visqueux
- Réduire la longueur du canal pour analyser l’effet du forçage

- Chauffer le film pour étudier l’effet du contre-écoulement sur le transfert de chaleur