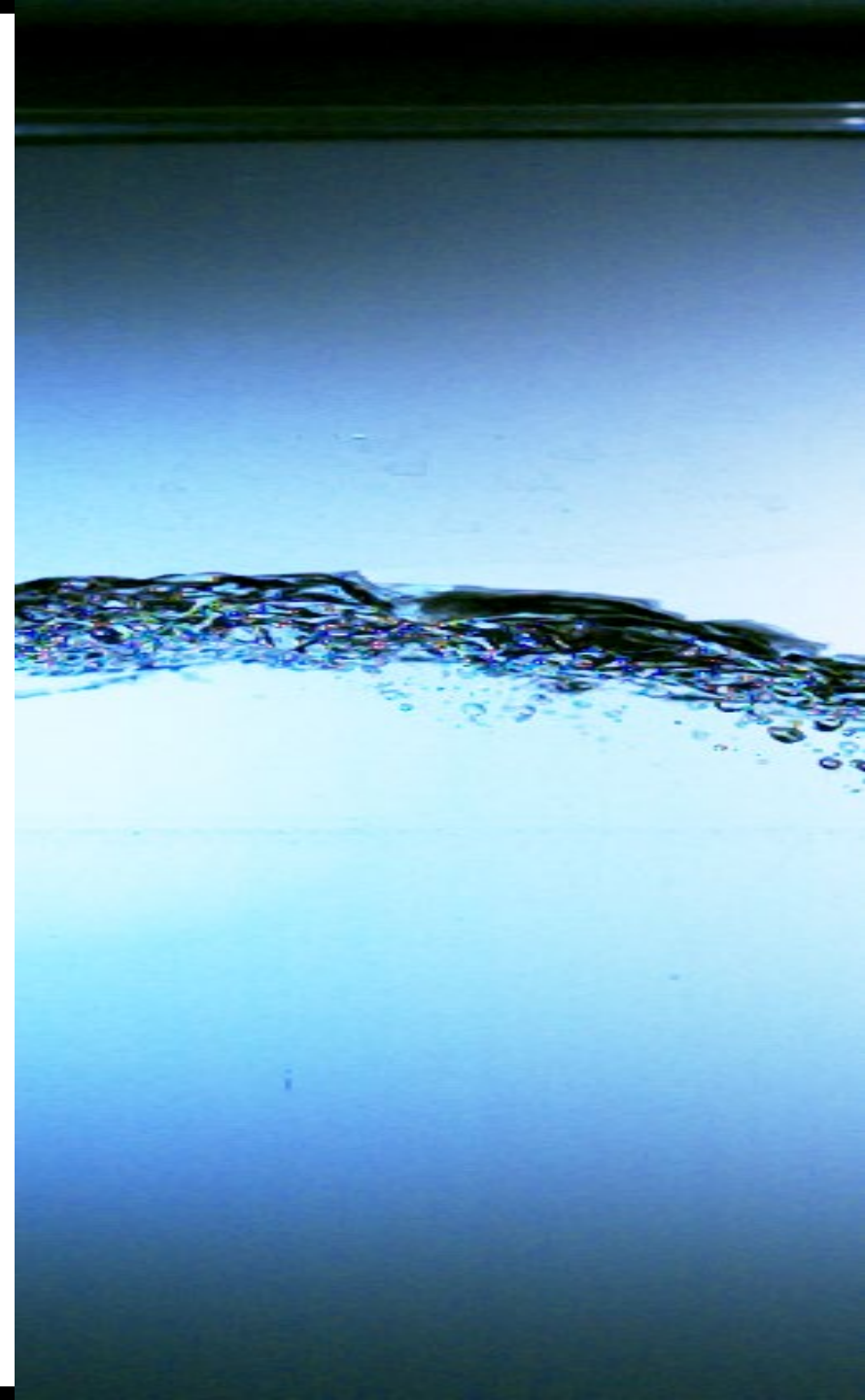# An experimental investigation of ocean bubbles and breaking wave crests

Konstantinos Chasapis[1]
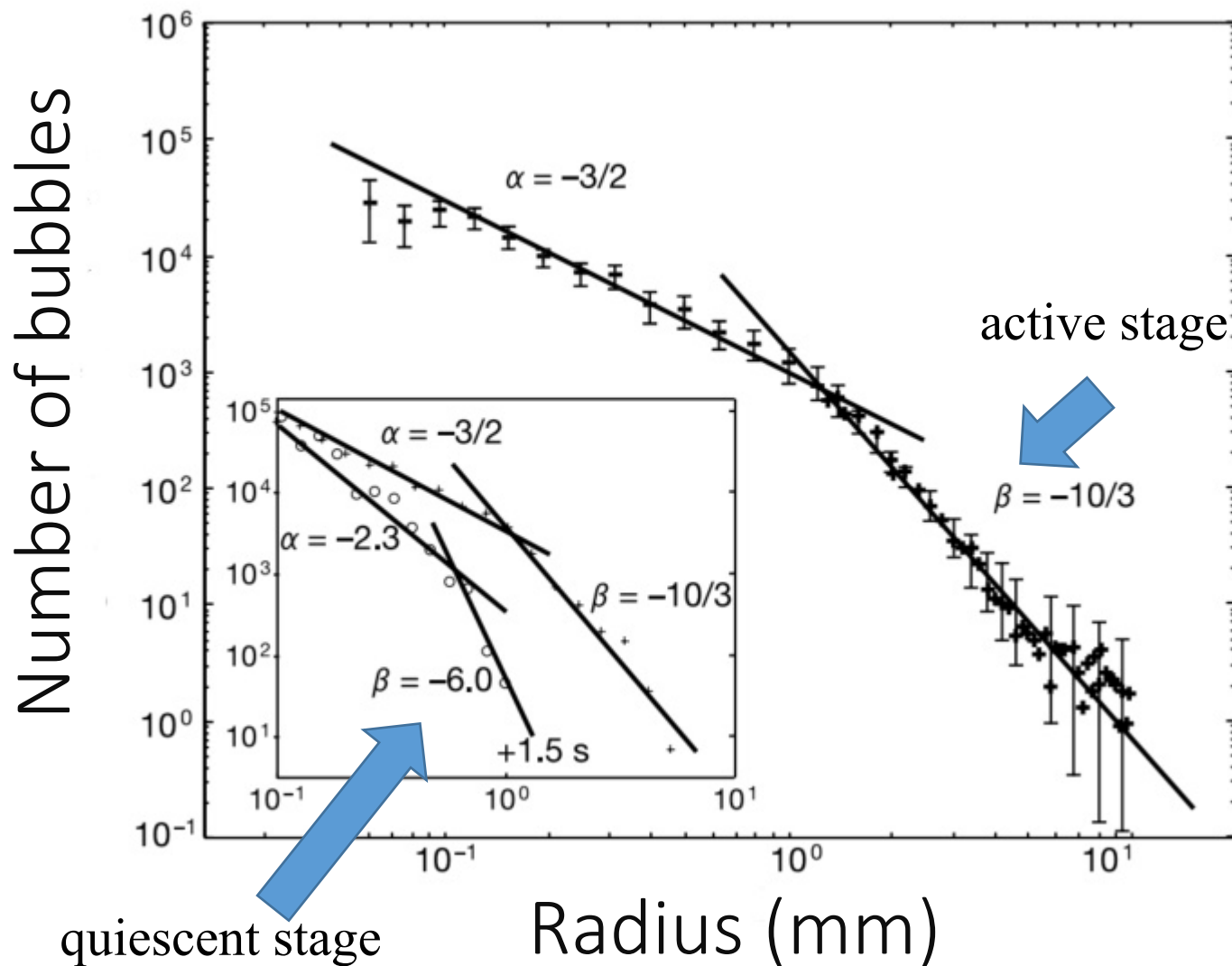
PhD candidate supervised by: Dr. Eugeny Buldakov[1], Dr. Helen Czerski[2]
[1] Department of Civil, Environmental and Geomatic Engineering, University College London
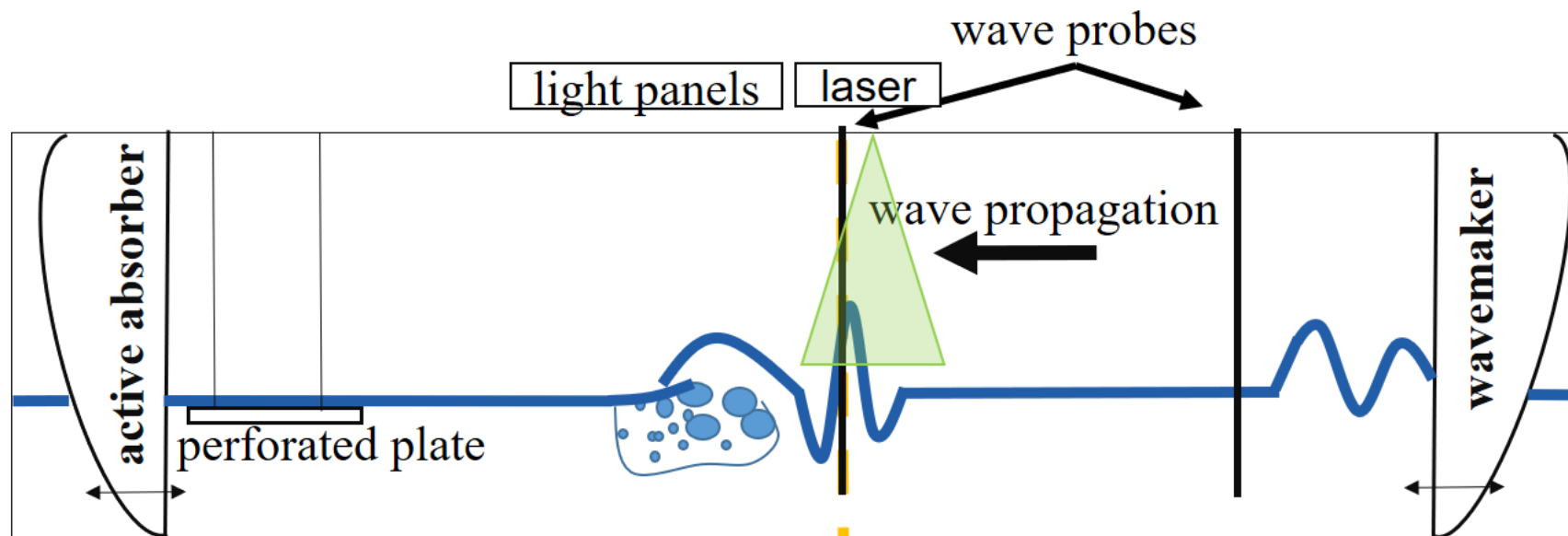[2] Department of Mechanical Engineering, University College London

The bubble size distribution and the evolution of bubbles

Number of bubbles

Radius (mm)

active stage

quiescent stage

$\alpha = -3/2$

$\beta = -10/3$

$\alpha = -3/2$

$\alpha = -2.3$

$\beta = -10/3$

$\beta = -6.0$

$+1.5$ s

Experimental procedures: laboratory set up with freshwater
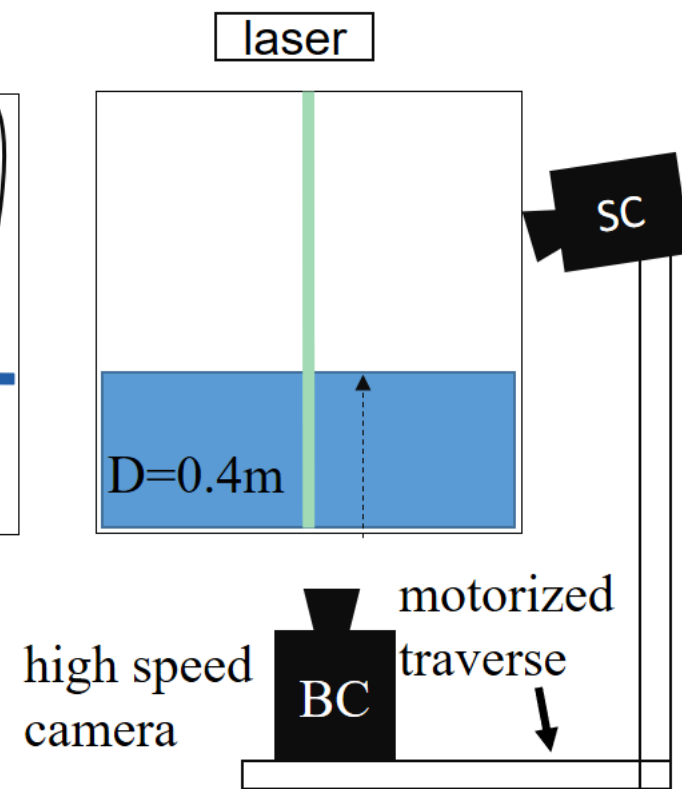
Experimental procedures: breaking wave generation

(a)

— target Gauss
--- x = -5 m
--- x = 0 m

(b)

$\Delta\phi = 0$: peak focused breaking wave

$\Delta\phi = \pi$: trough focused breaking wave
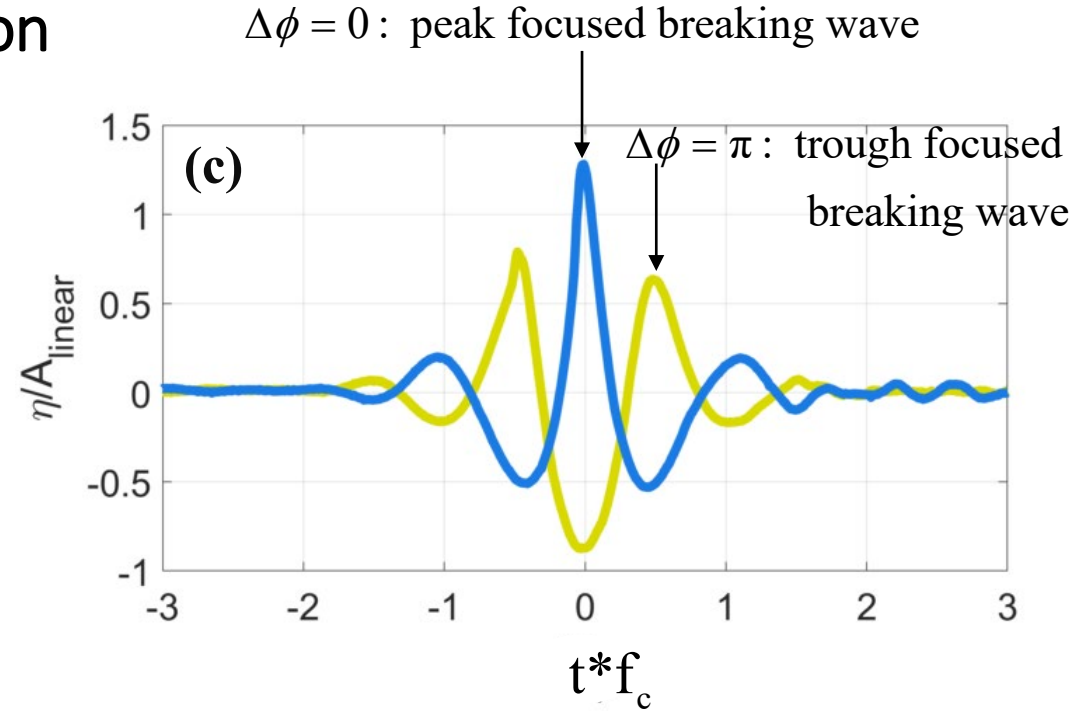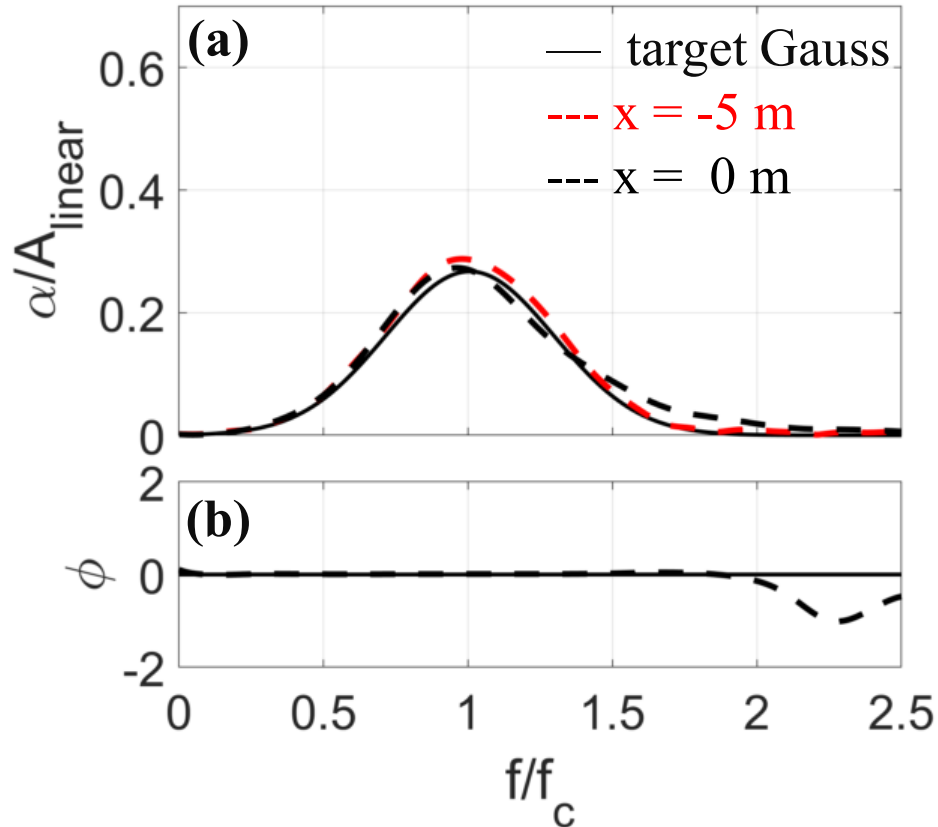
$$\eta(t) = \sum_{i=1}^{I} \alpha_i \cos\left(\omega_i t + \Delta\phi\right)$$

η : surface elevation each packet component i

α : wave amp determined by spectrum

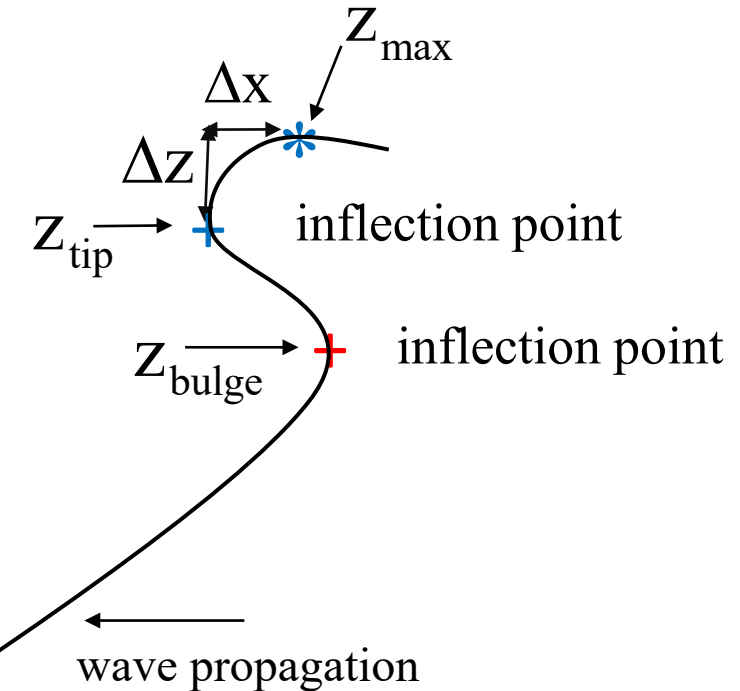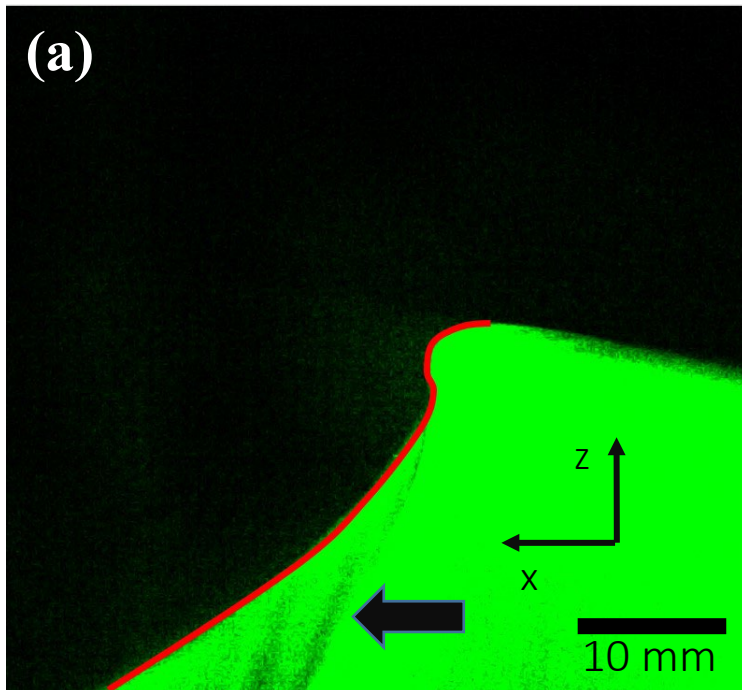ω : $2\pi f_i$ angular frequency

$\Delta\phi$: phase each packet component

Dispersive focusing of wave packets.
Linearized spectra match target Gaussian spectrum.

Experimental procedures: wave crest extraction and breaking location

(b) breakers with detected bulges

$$\text{local deformation slope } \Gamma = \frac{z_{max} - z_{tip}}{x_{max} - x_{tip}} = \min$$

Experimental procedures: bubble analysis

A feature extraction algorithm was written and used to detect bubbles with circular shapes in 2D images.

Main processing tool for bubble detection: Hough transform

Technical details:

2000fps – 1/4000 shutter speed

10^6 images analysed
    program written in Matlab.

(a)
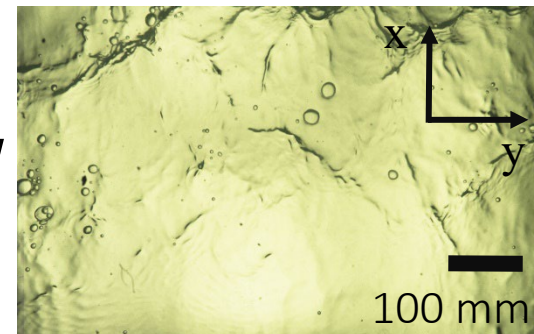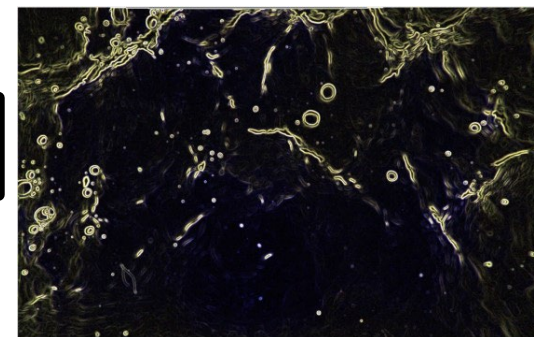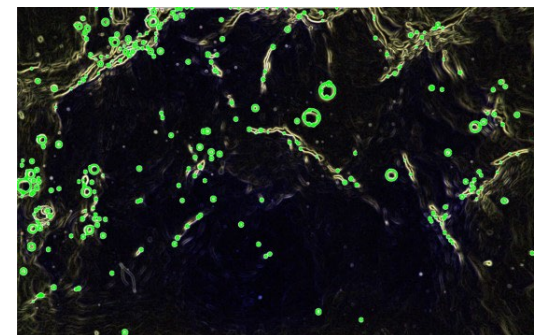
Raw Image

x

y

100 mm

(b)

Image pre processing
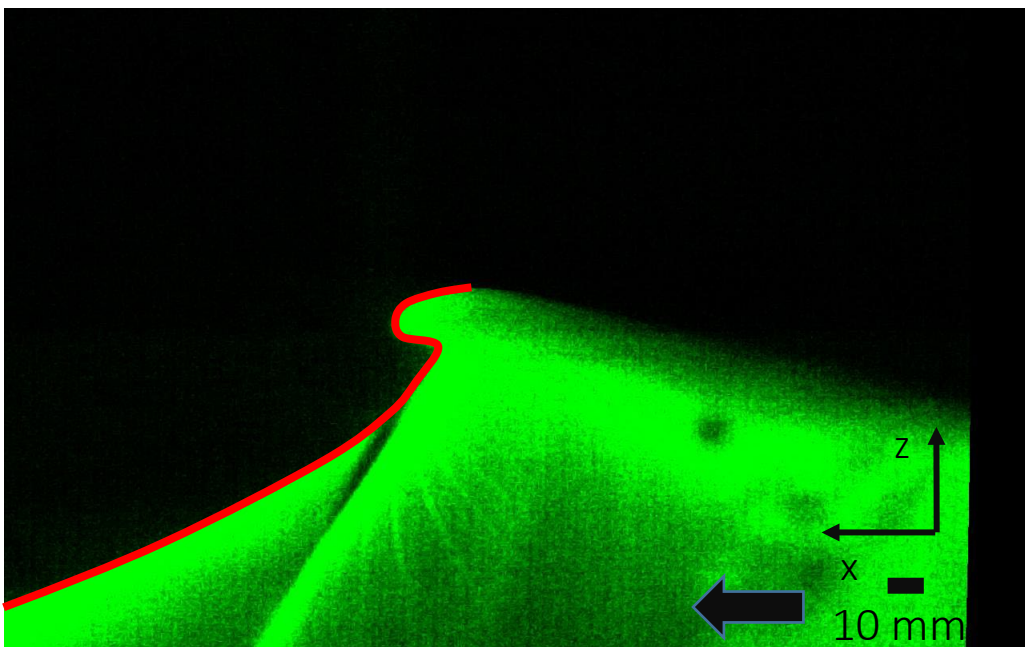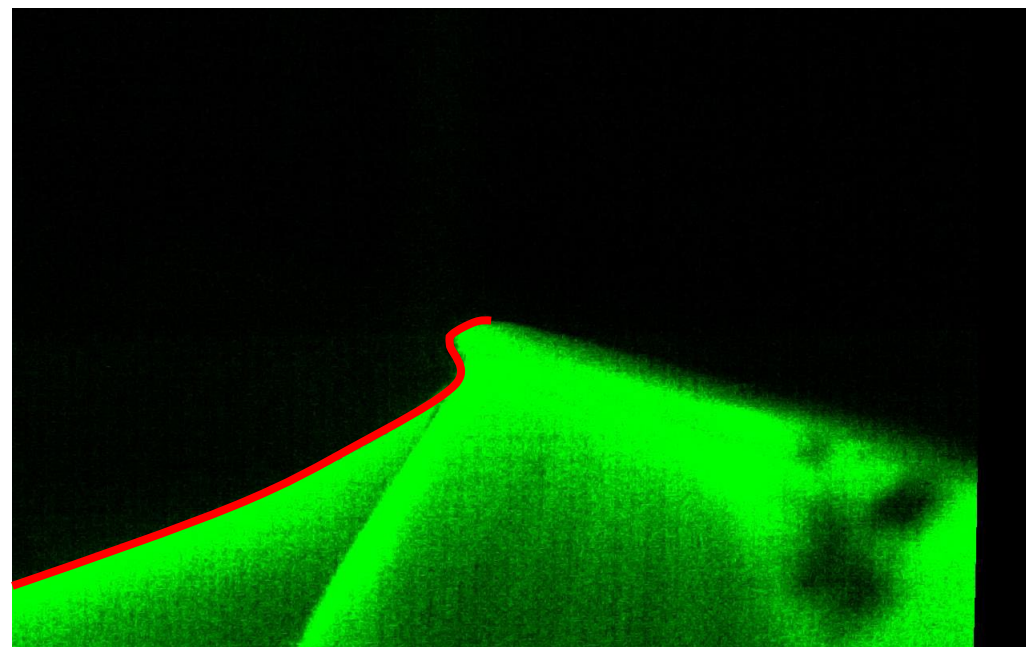
(c)

Feature extraction algorithm

(d)

Output: coordinates and radii

Results: qualitative comparison of breakers at breaking location
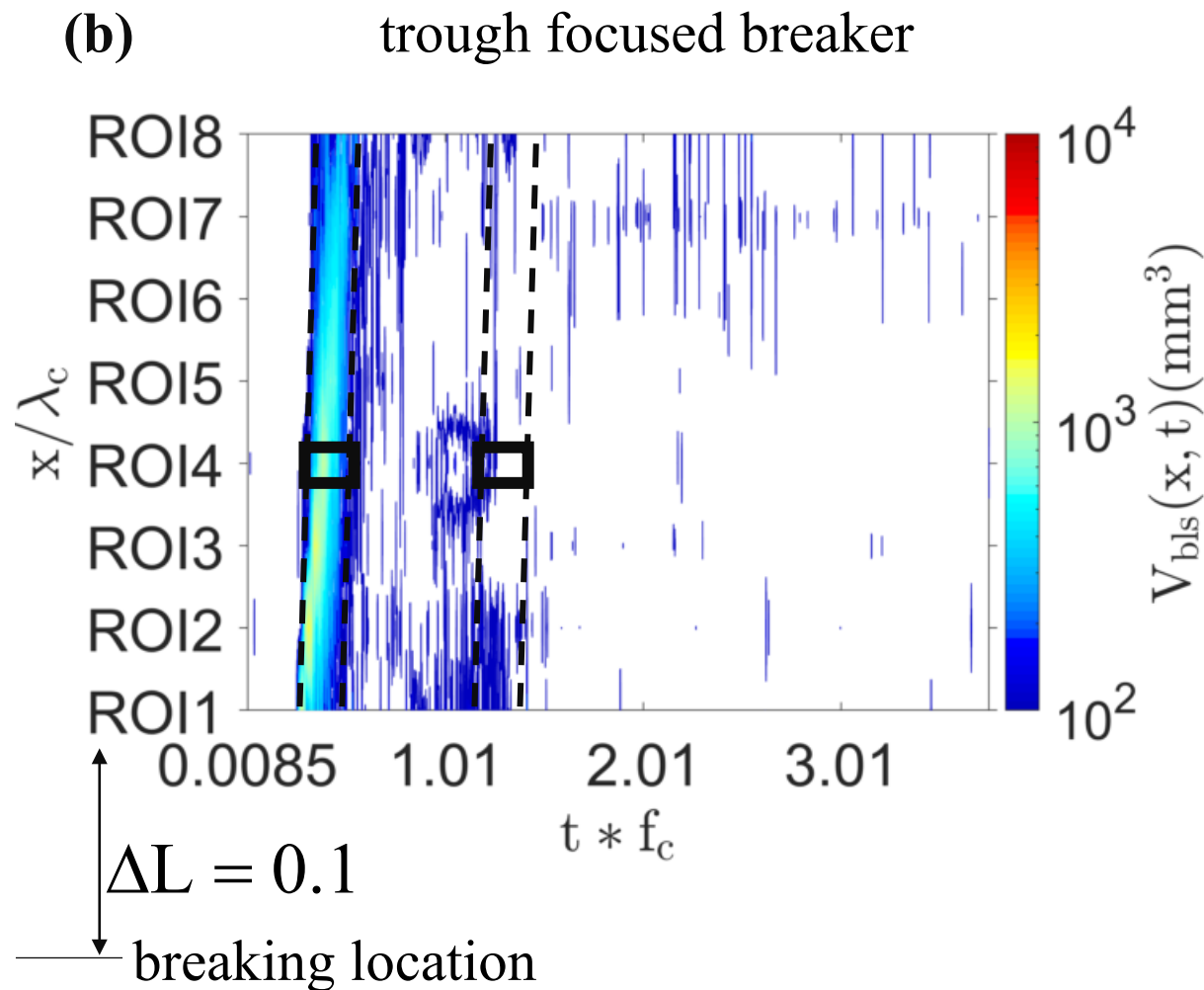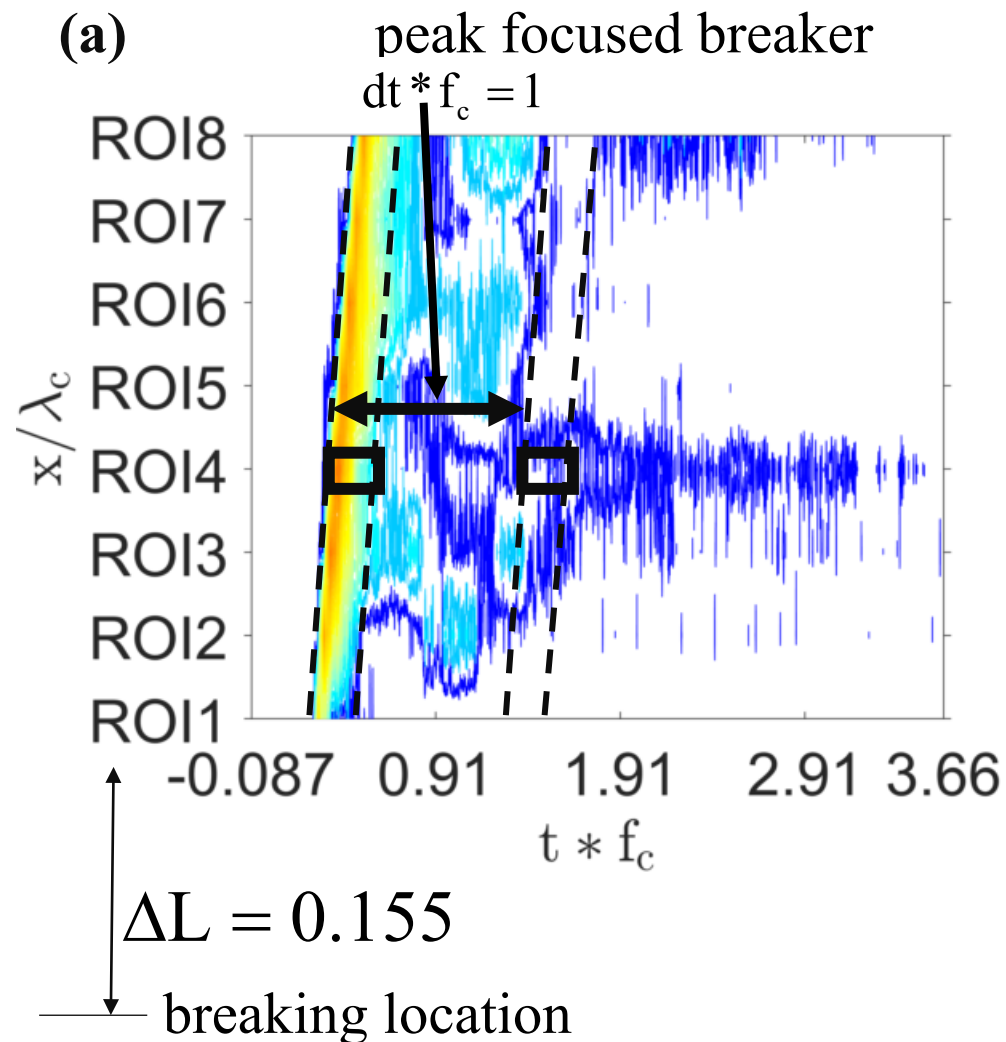
(a) peak focused breaker

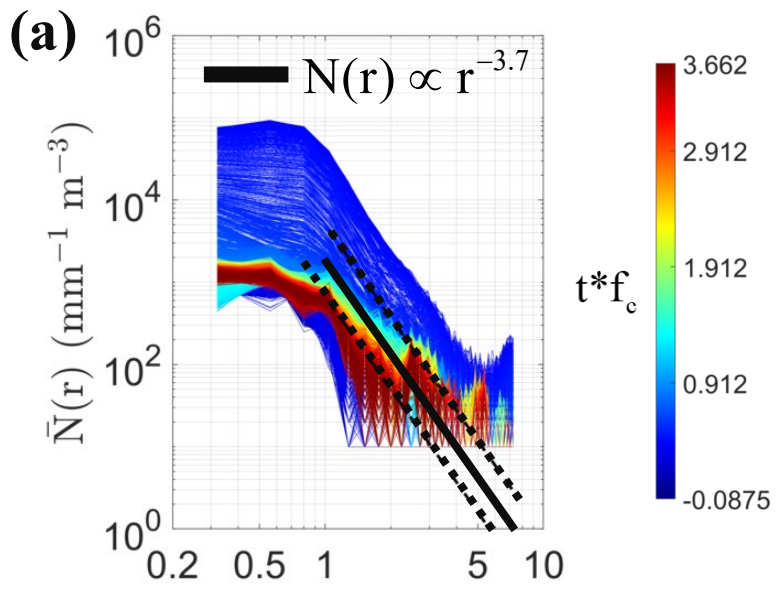**(b)** trough focused breaker

── overlaid extracted crest

Results: evolution of bubble volume

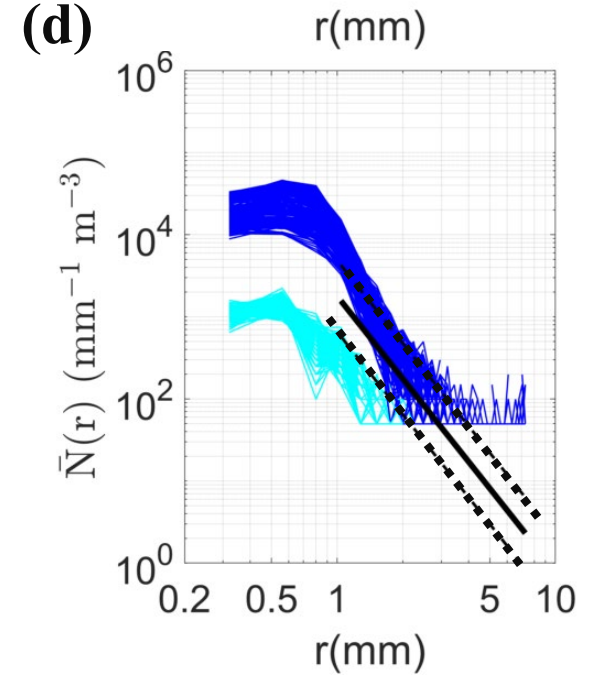# Results: bubble size distributions

BSD full evolution ROI4
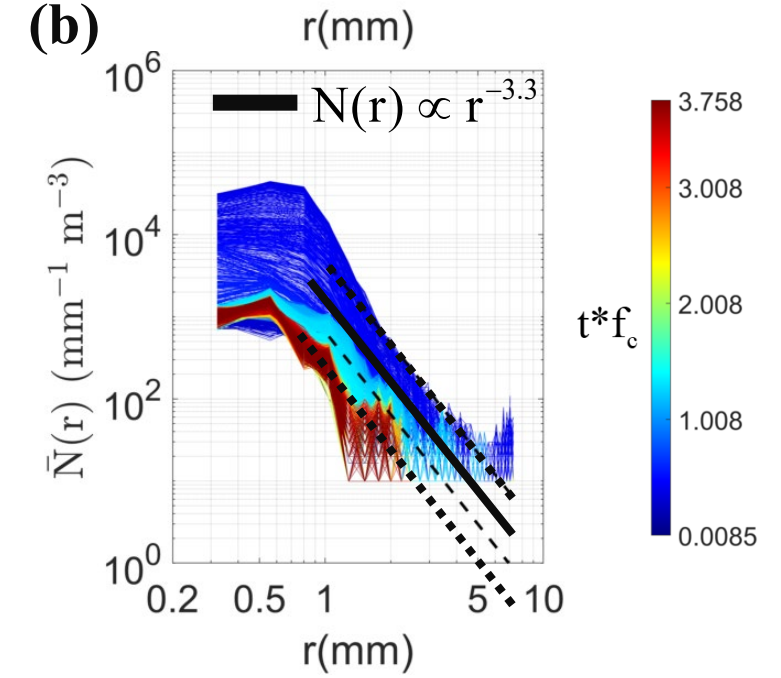
BSD time selection ROI4

(a) $N(r) \propto r^{-3.7}$

peak breaker

(b) $N(r) \propto r^{-3.3}$
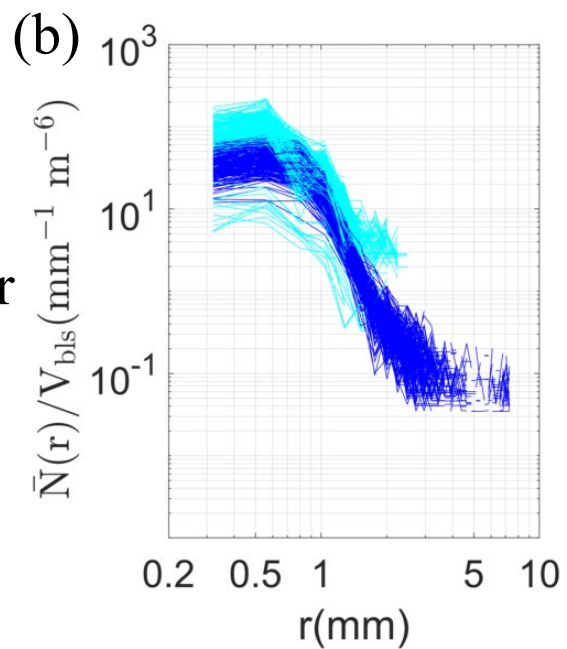
trough breaker

(c) time interval 1, time interval 2

(d)

Discussion

(a) normalised BSD
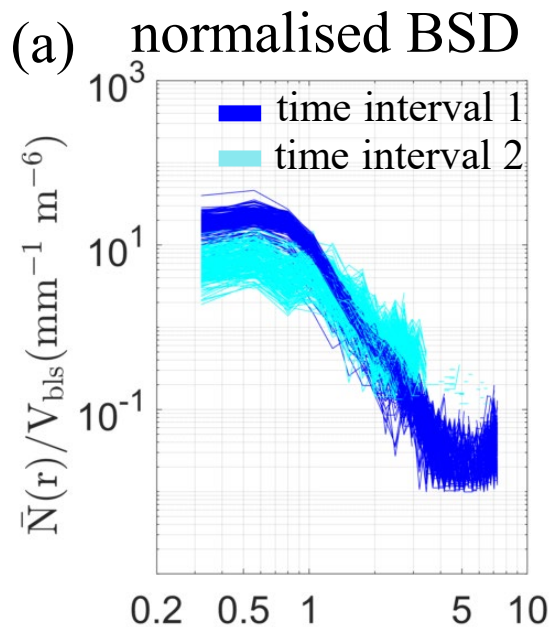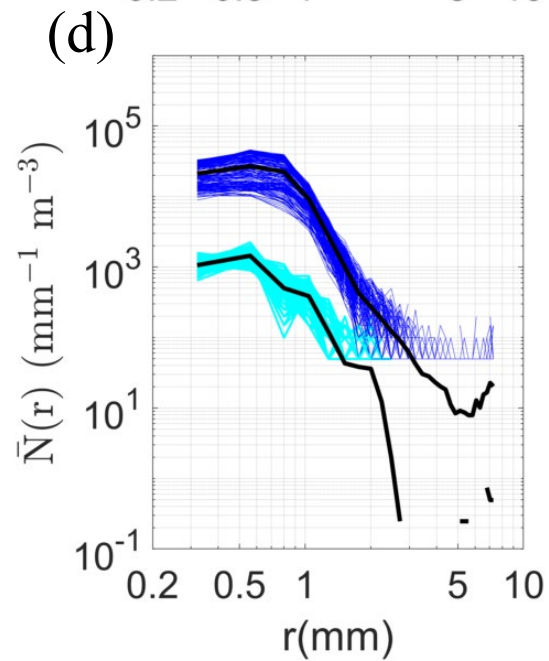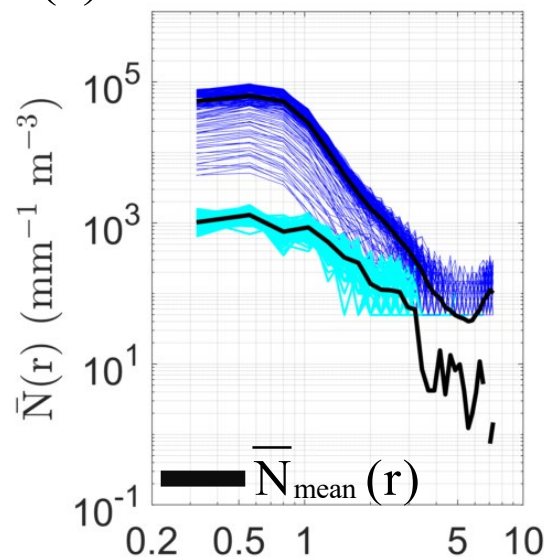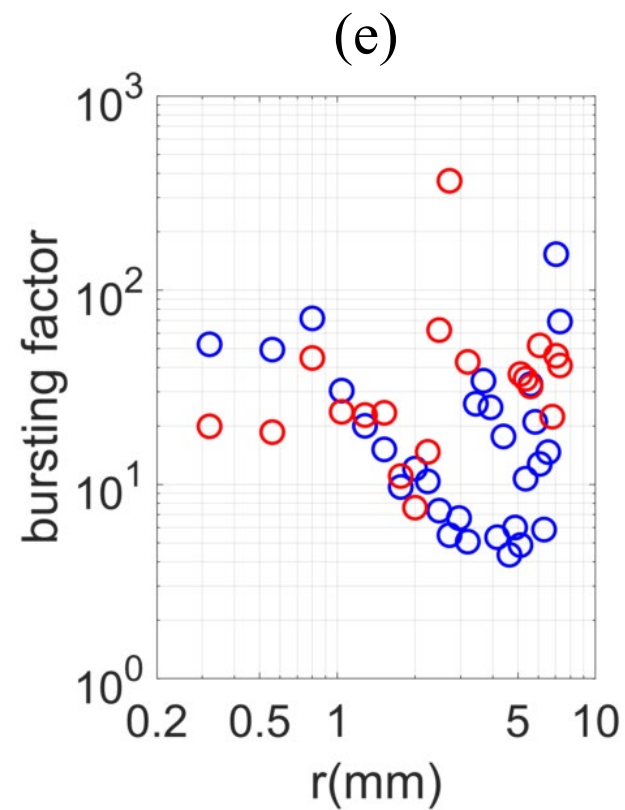
(c) time-averaged BSD

bubble bursting

peak breaker

trough breaker

Conclusions – future work

❑ Wave deformation was demonstrated for a peak and trough breaker.
Peak breaker →10 times more max bubble volume each ROI.
        → 5 times more bubbles than trough, and 10 times for r > 2mm each ROI.

❑ Bubble evolution for more types of phase shifts were tested, but trough focused ones stood out.

❑ Experiments allow for estimation of bubble lifetimes and burst size for various breakers.

❑ Saltwater experiments are the next step.

Thank you!