

LARGE-SCALE LABORATORY EXPERIMENTS ON TSUNAMIS GENERATED BY SUBMARINE VOLCANIC ERUPTIONS IN A WAVE BASIN



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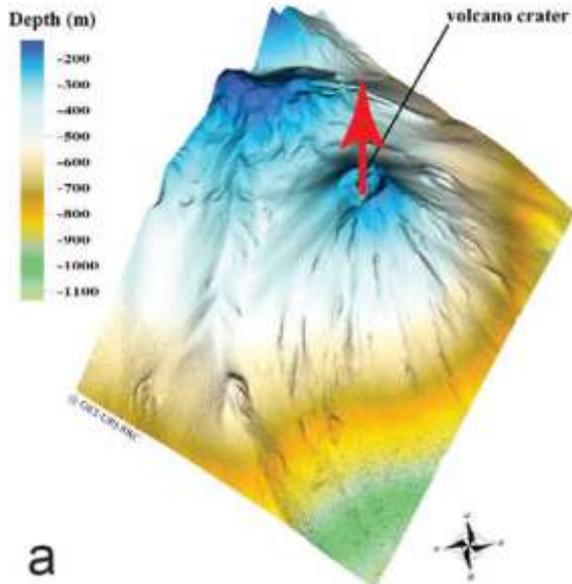
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BY

Volcanic tsunami scenarios



(Nautilus Research Cruise, 2013)



(Howell, 2007)

a) Kick 'em Jenny, Caribbean Sea

b) & c) Kavachi, Solomon Islands

d) & e) Mud volcano, Arabian Sea



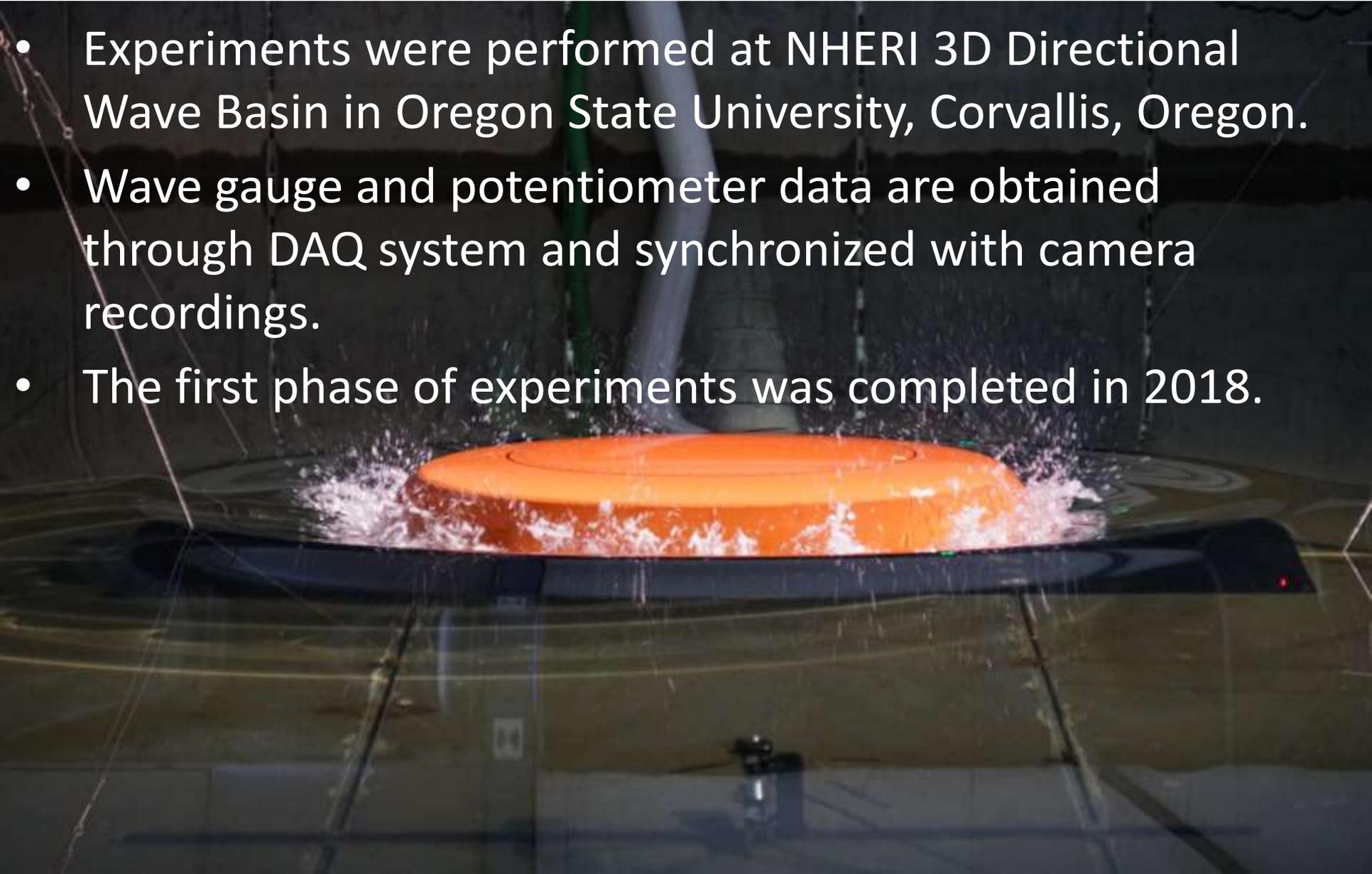
Limited event records and field data

Complex source mechanisms

(Heidarzadeh and Satake, 2014; Akhtar, 2015)

Experiments at NHERI, Oregon State Univ.

- Experiments were performed at NHERI 3D Directional Wave Basin in Oregon State University, Corvallis, Oregon.
- Wave gauge and potentiometer data are obtained through DAQ system and synchronized with camera recordings.
- The first phase of experiments was completed in 2018.



Experimental Parameters

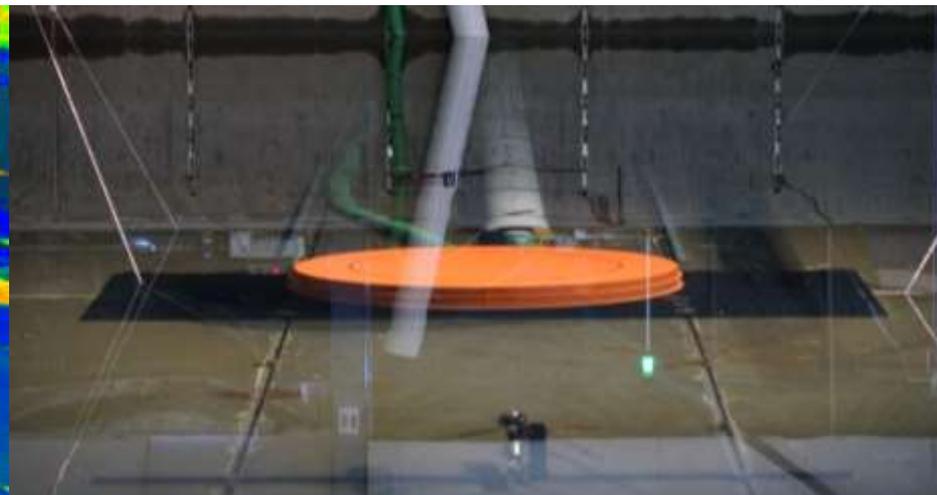
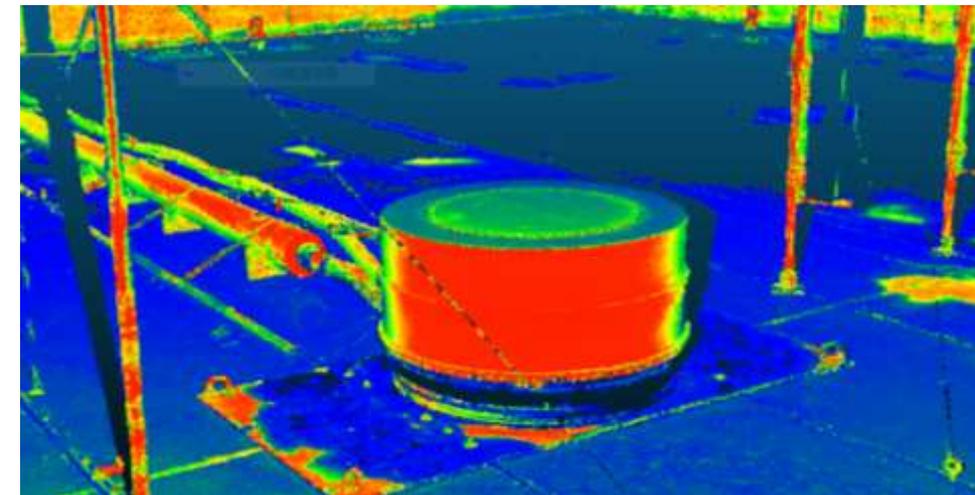
- Around **120 combinations** of various water depth and pressure settings have been tested.
- More than **300 runs** in total including column collapse scenario and repetitions for statistical analysis.
- The range of water depth in the directional wave basin is between 0.73 and 1.50 m.

Volcanic Tsunami Generator Design and Manufacturing

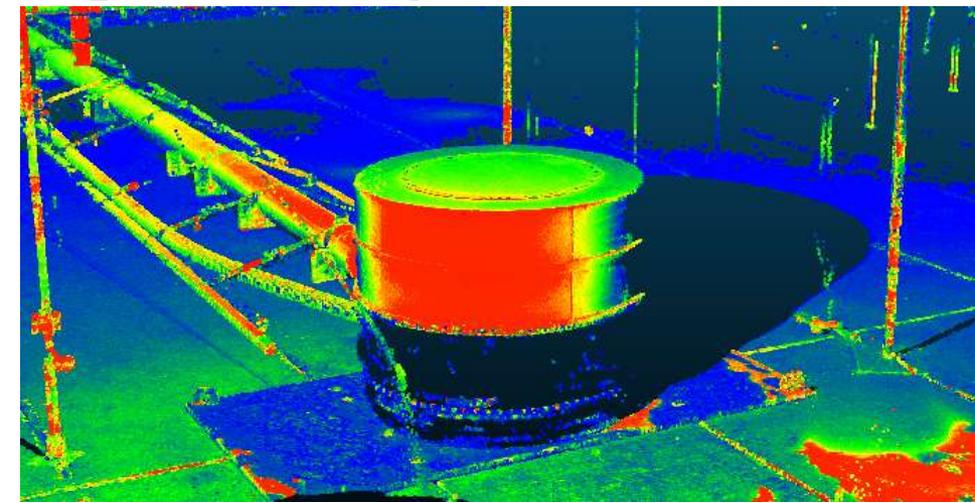


Stages of motion

Retracted stage (LiDAR intensity image)



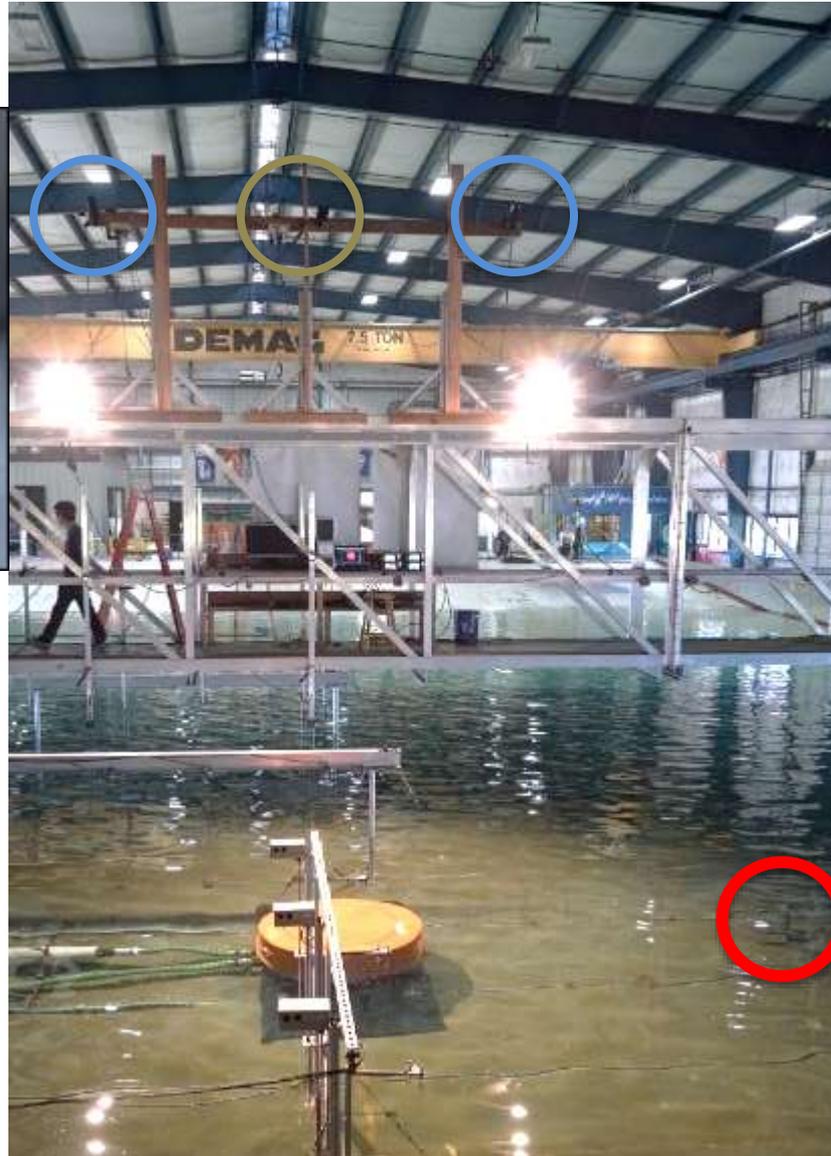
Expanded stage



Experiment Setup

Camera setup

Edgertronic
high speed camera



LaVision Imager Pro X



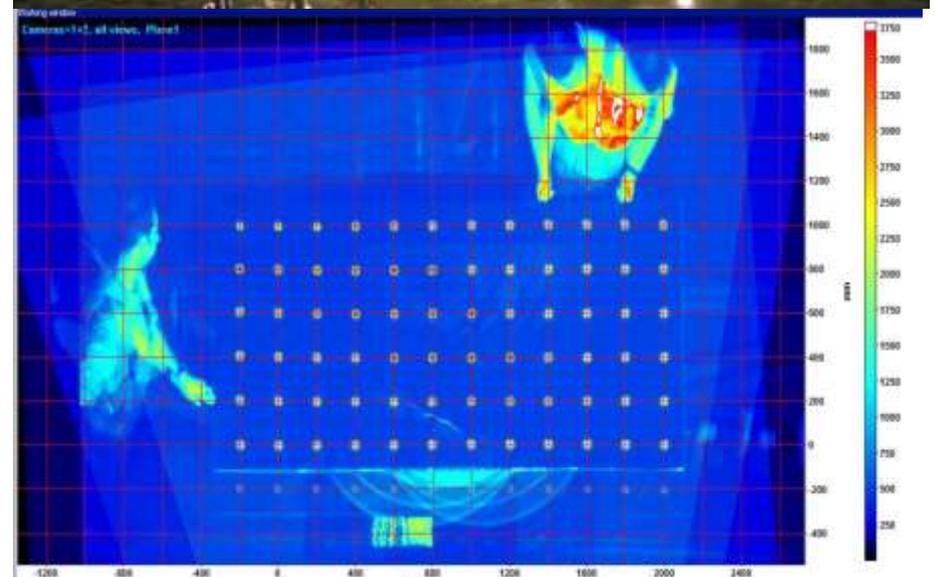
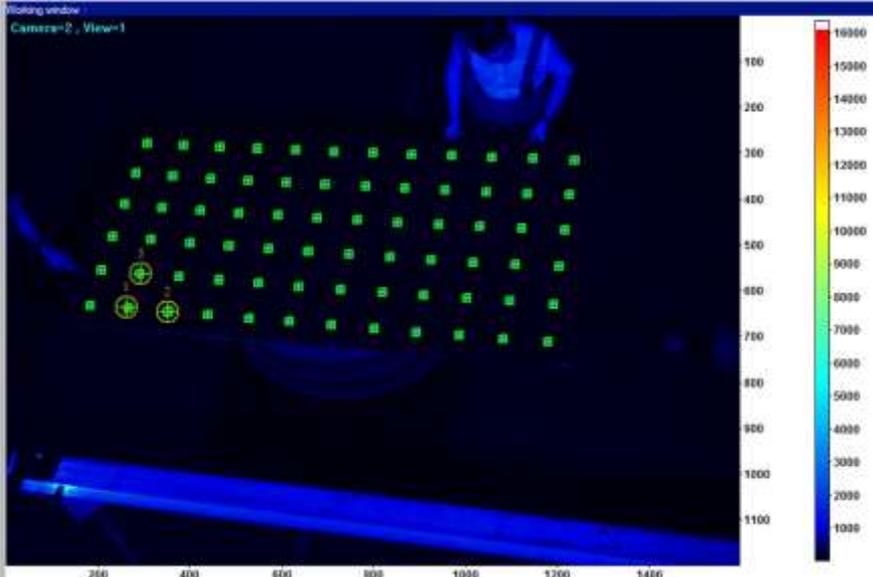
Panasonic PTZ camera



Delta Vision HD
underwater camera



Calibration of underwater and PIV cameras

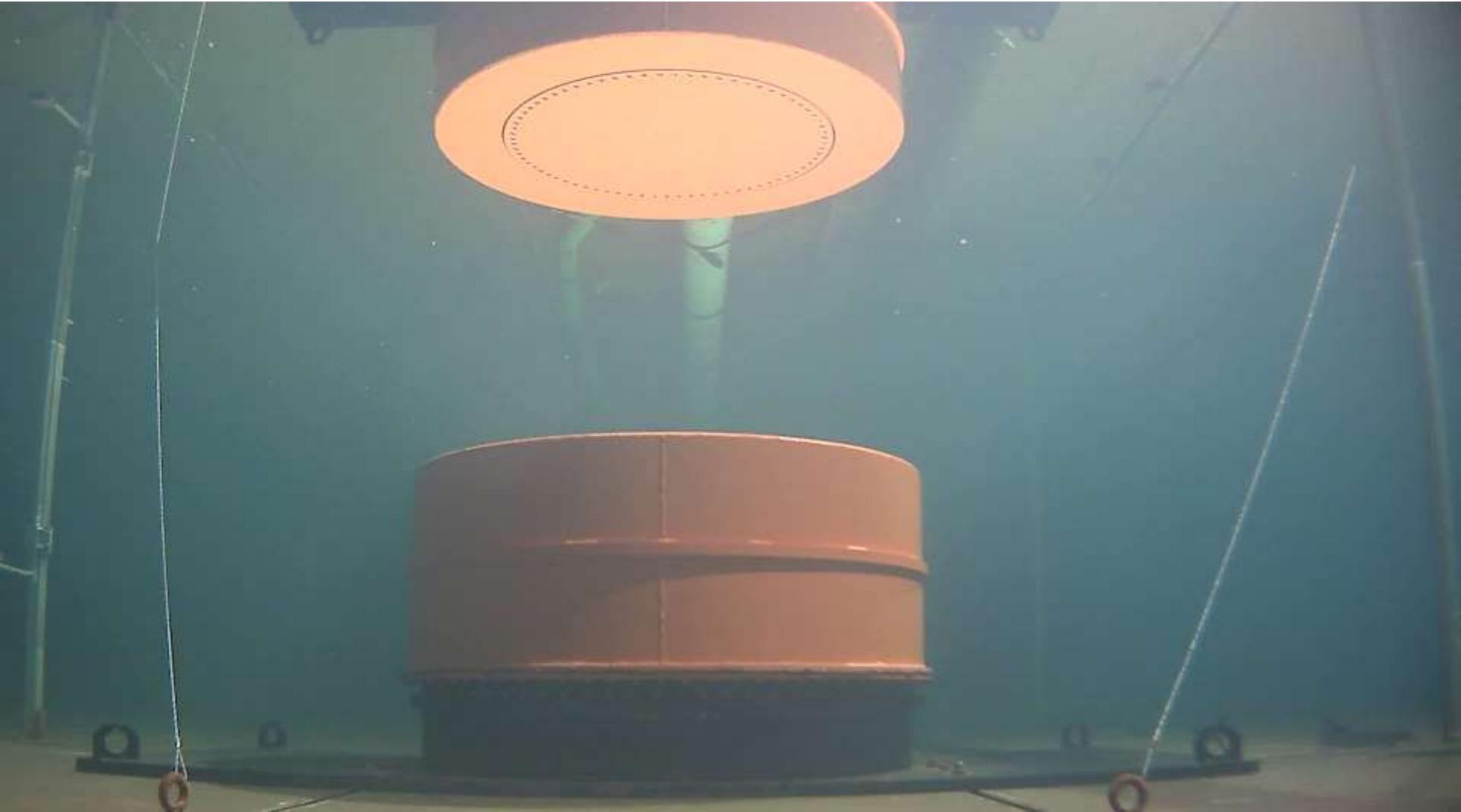


Results and Discussion



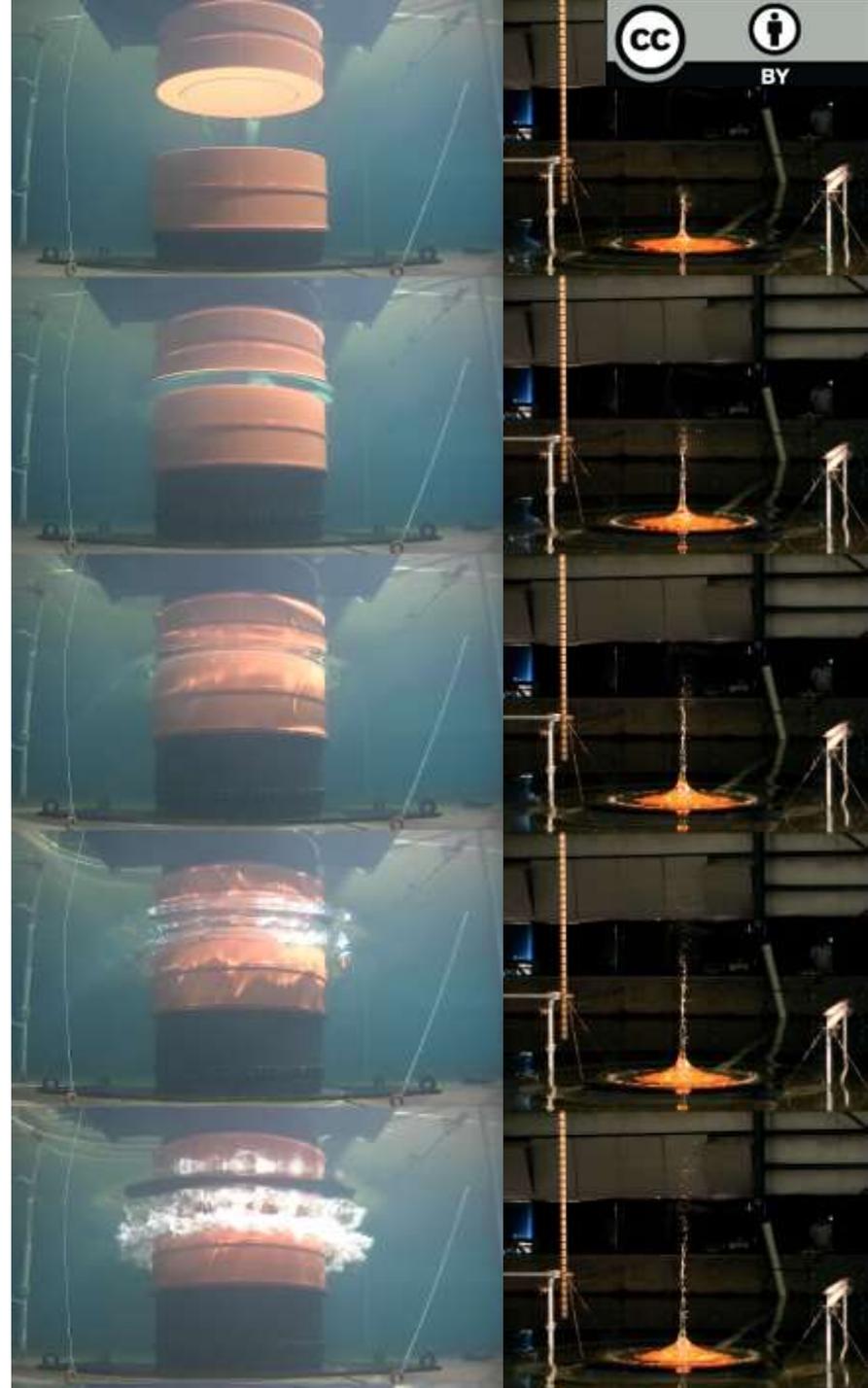
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Underwater view of fully submerged run

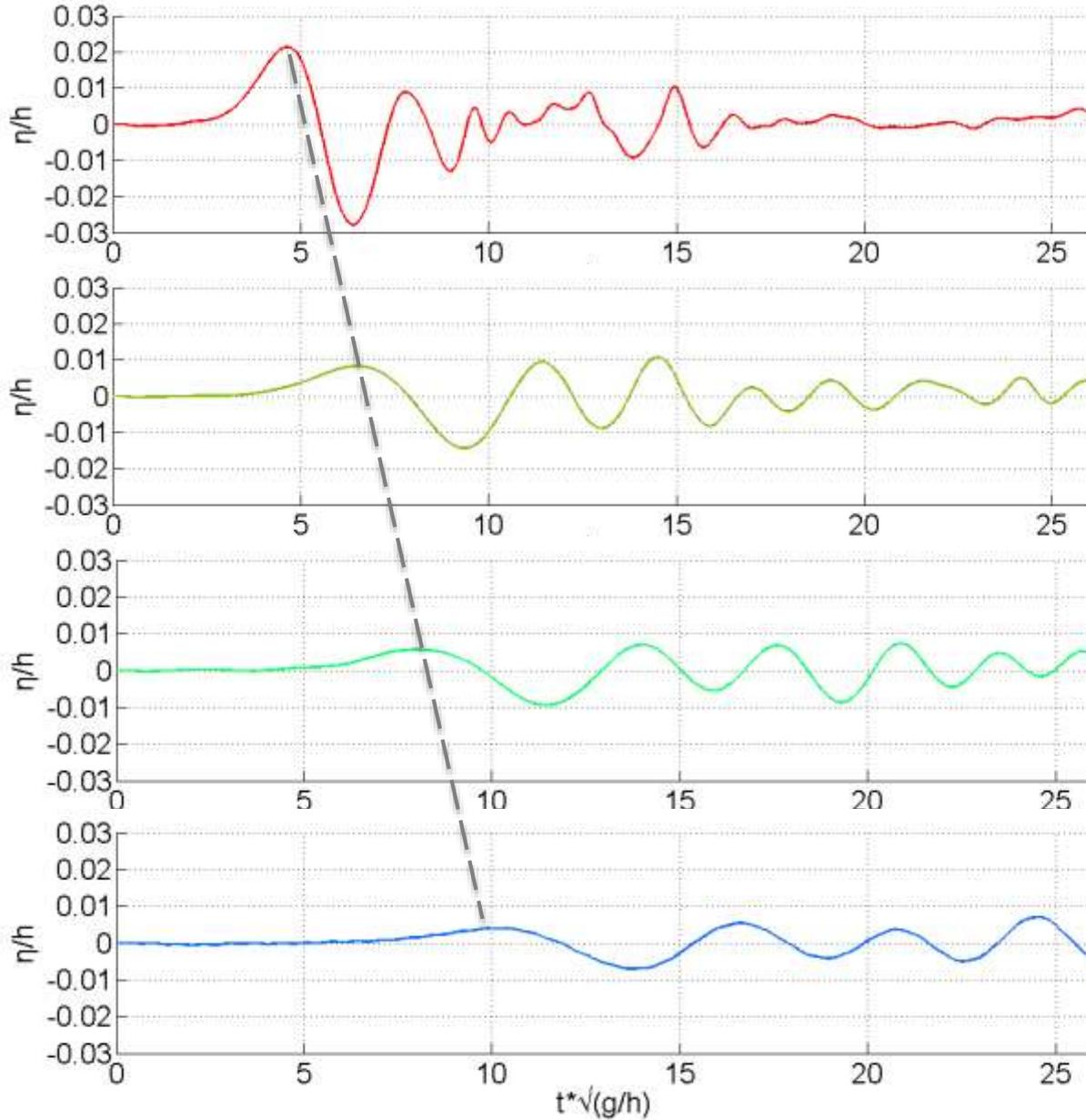


Generation of surface spike

- The concentric vertical spike can be observed after the rising phase of VTG under a limited range of water depths.
- Formed by superposition of the first inner propagation wave crest during the bore formation.
- There are various types of spike profile which can be classified by Froude number and relative diameter.



Wave gauge time series



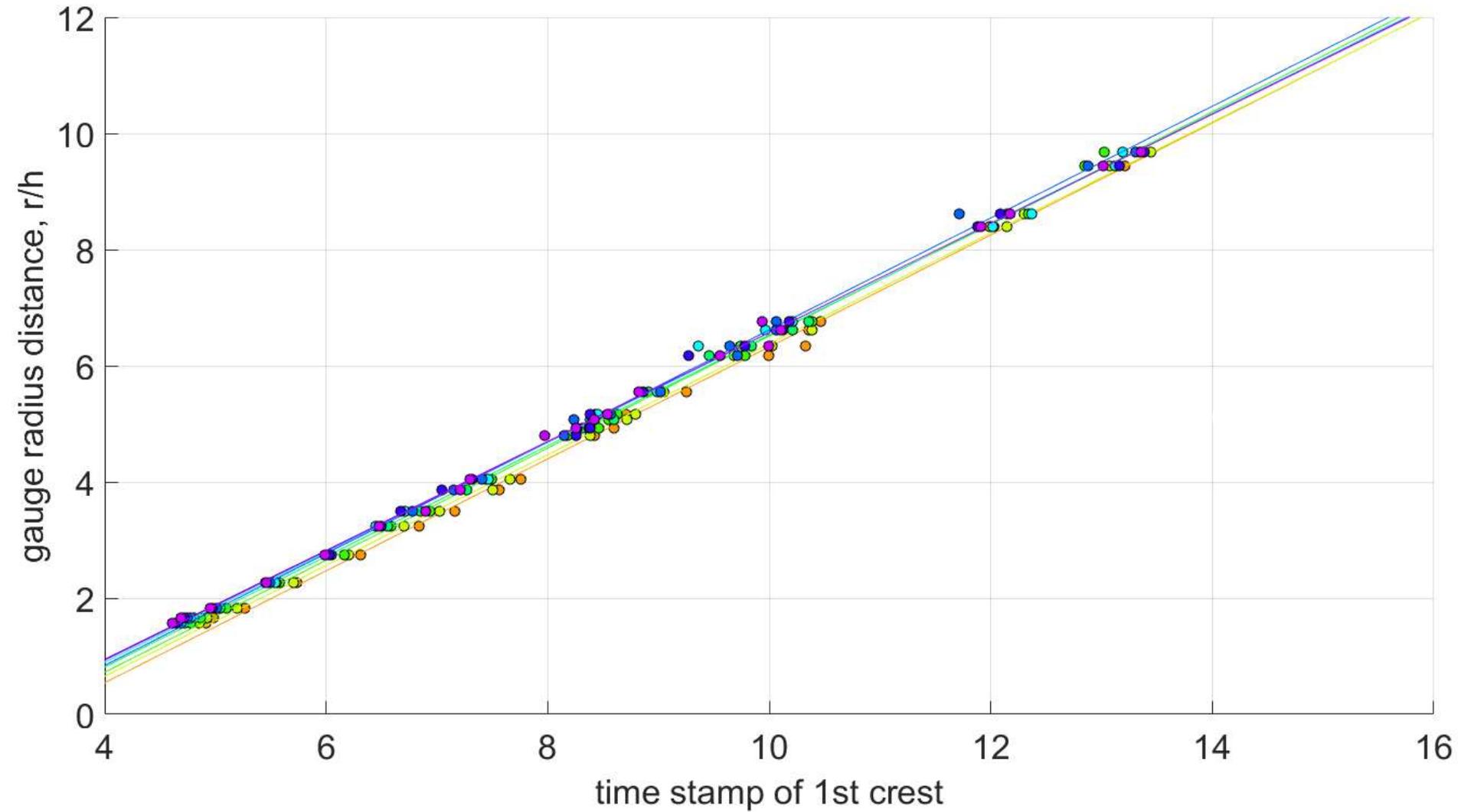
$r/h = 1.6$

$r/h = 3.2$

$r/h = 4.8$

$r/h = 6.6$

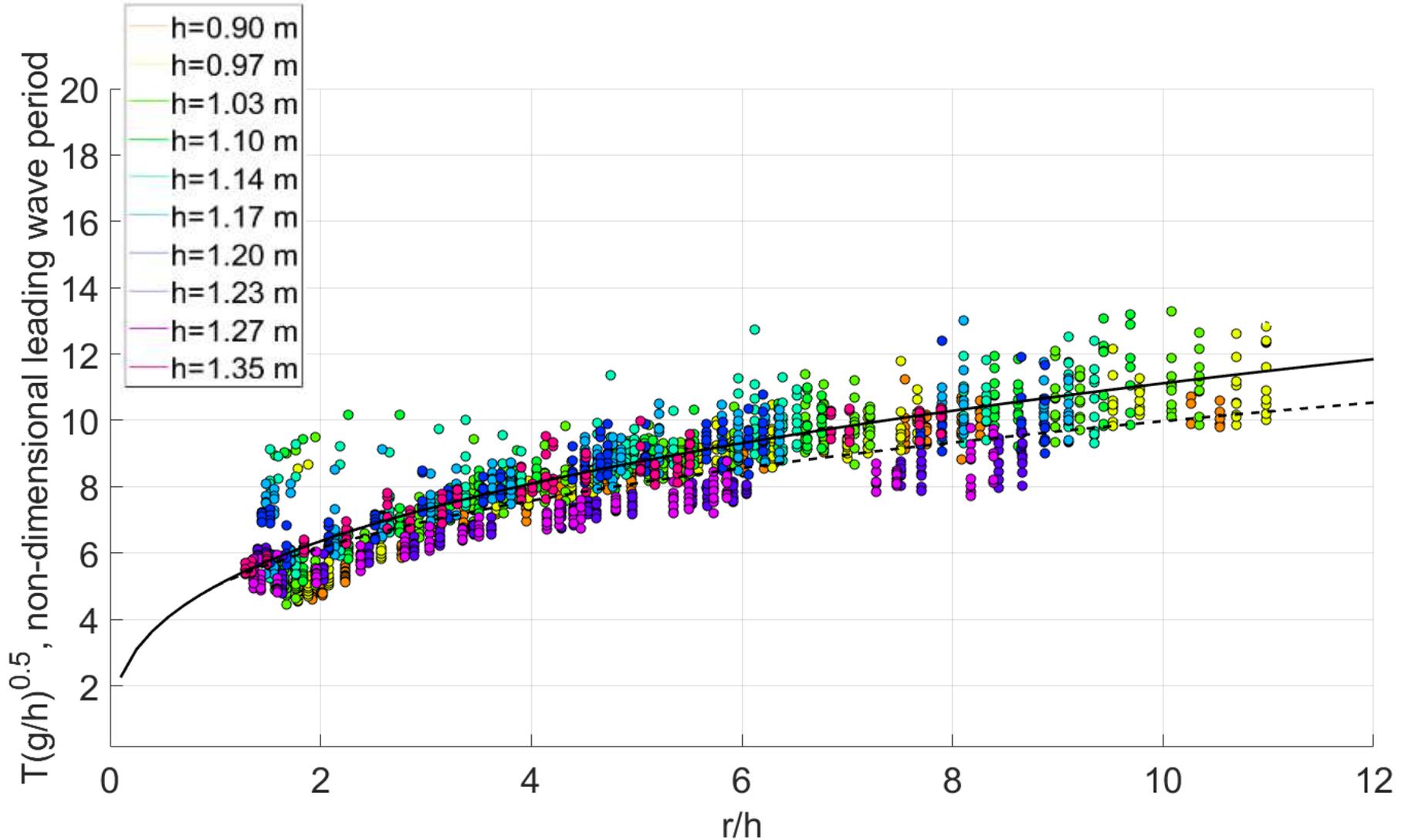
Wave propagation of the first crest



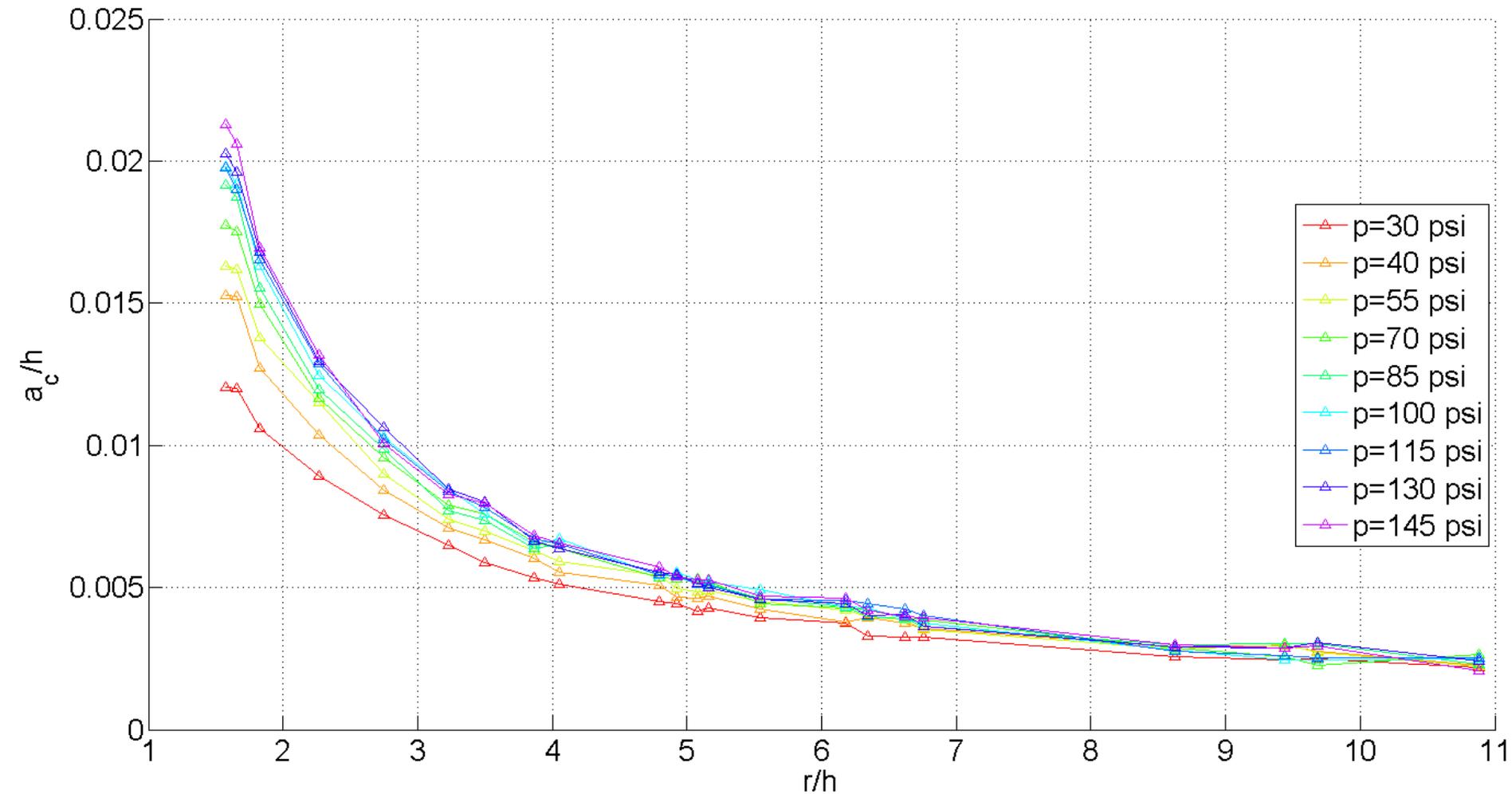
Wave celerity $\in [3.01, 3.17]$ m/s from linear regression.
Long wave approximation at this depth is ~ 3.28 m/s .

Non-dimensional wave period

$$T \left(\frac{g}{h} \right)^{0.5} = k_r \left(\frac{r}{h} \right)^c = 5.0 \left(\frac{r}{h} \right)^{0.35}$$

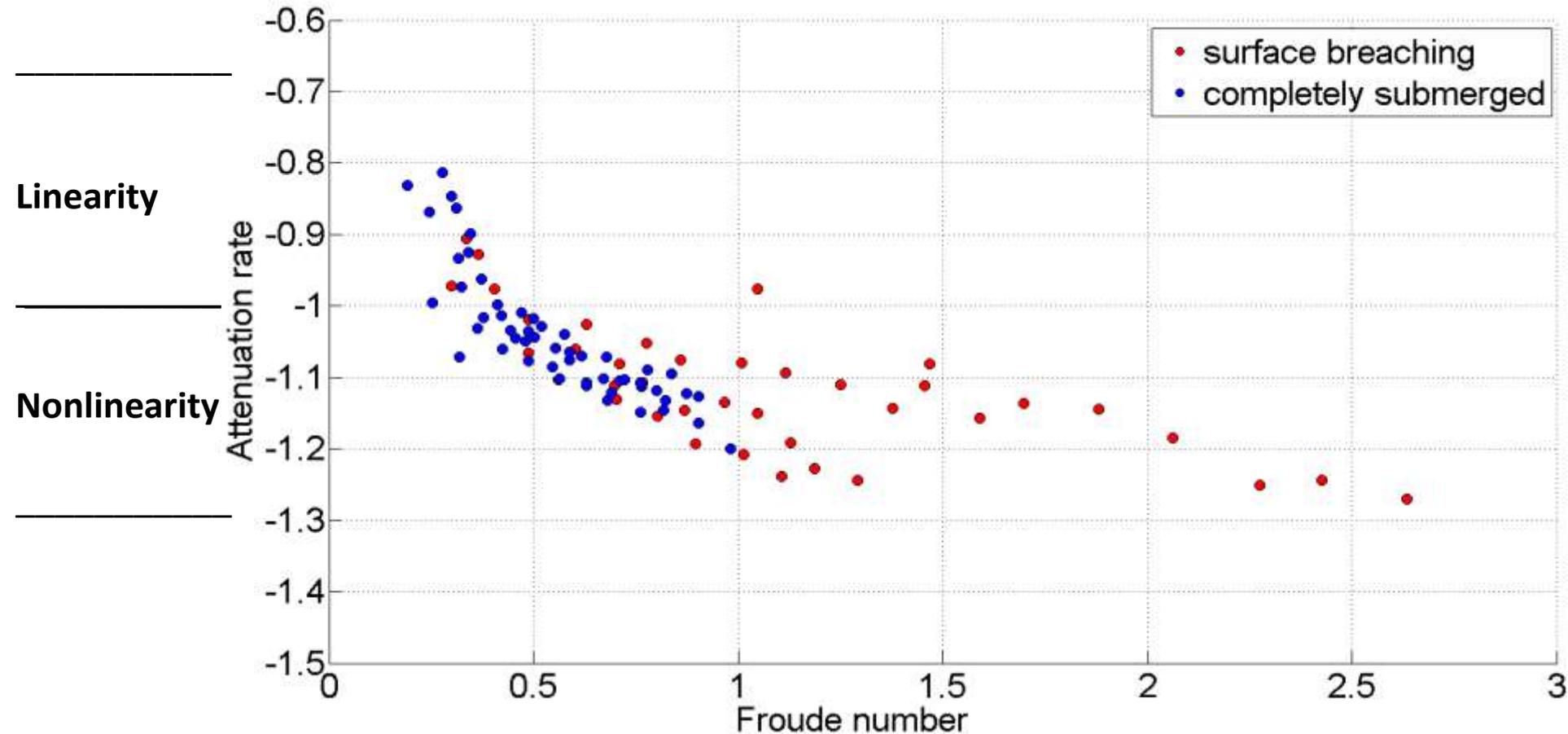


Attenuation of leading wave



Attenuation of leading wave

Power function fitting: $\frac{a_c}{h} = k \cdot \left(\frac{r}{h}\right)^c$



Concluding Remarks

- Volcanic tsunami generator (VTG) was designed, manufactured and deployed.
- More than 300 experimental runs are performed at NHERI 3D Directional Wave Basin in Oregon State University, Corvallis, Oregon in 2018.
- Experimental program includes the following scenarios: surface piercing, fully submerged eruption and collapse of the eruptive column.
- Wave gauge and potentiometer data are obtained through DAQ system and synchronized with camera recordings.
- The underwater piston-type wave maker generates the surface spike from the concentric collision of the first wave crest, which only exists under a limited range of water depth and Froude number.
- The attenuation rate of the leading wave may exceed the range (-1.0, -0.7) predicted by the linear wave theory for larger Froude number scenarios.
- Further work will focus on the generation mechanisms and quantitative analysis of the propagation and run up of the cylindrical waves generated by the underwater vertical piston-type wave maker.

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Thanks for your attention!



Liu and Fritz, 2020

