

Characterization of sound induced by bubbles released from nozzles

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(Preliminary results)

Funding from Gulf Research Program of the National Academy of Sciences

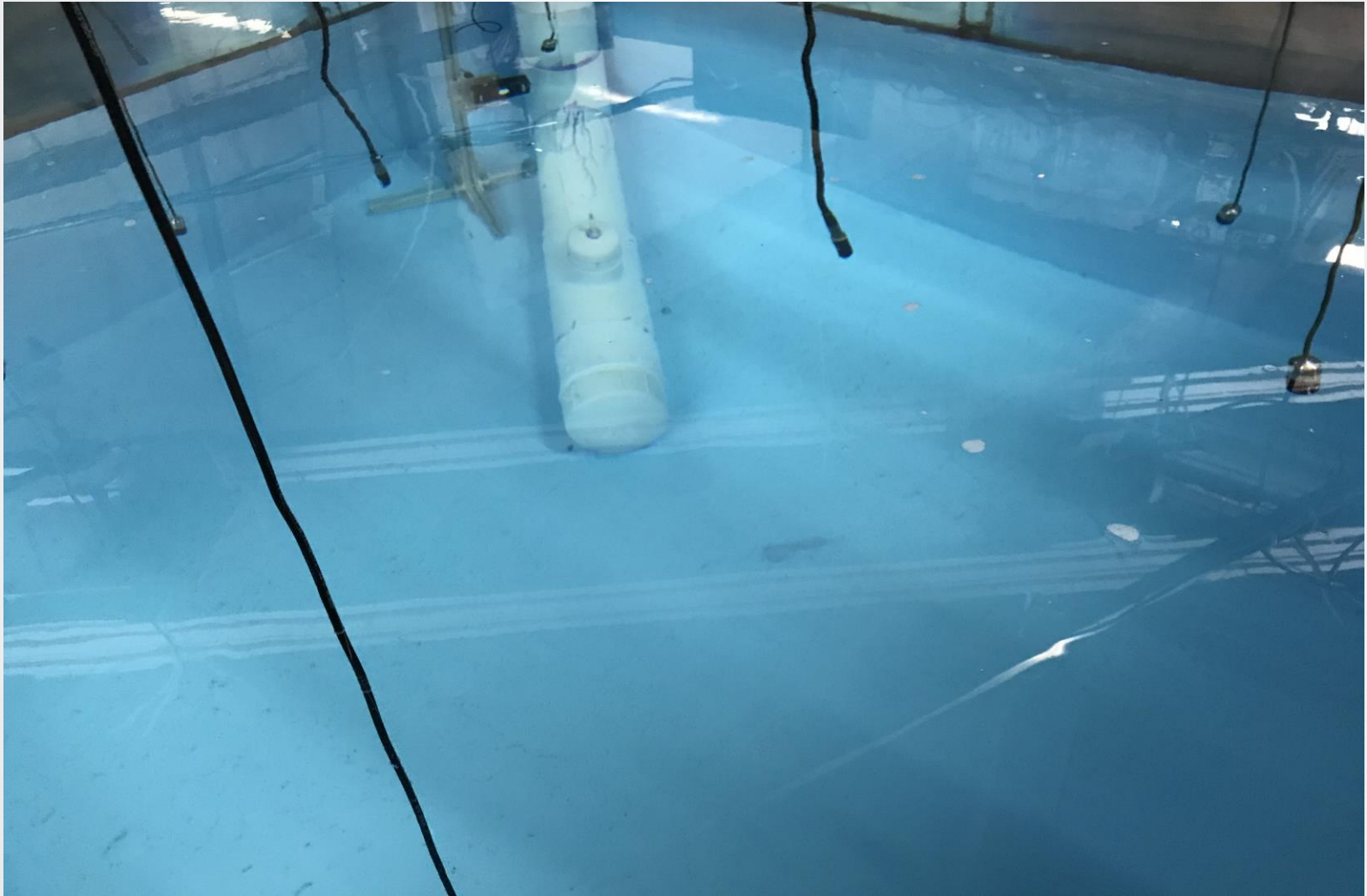
Problem and Motivations: Oil leakage



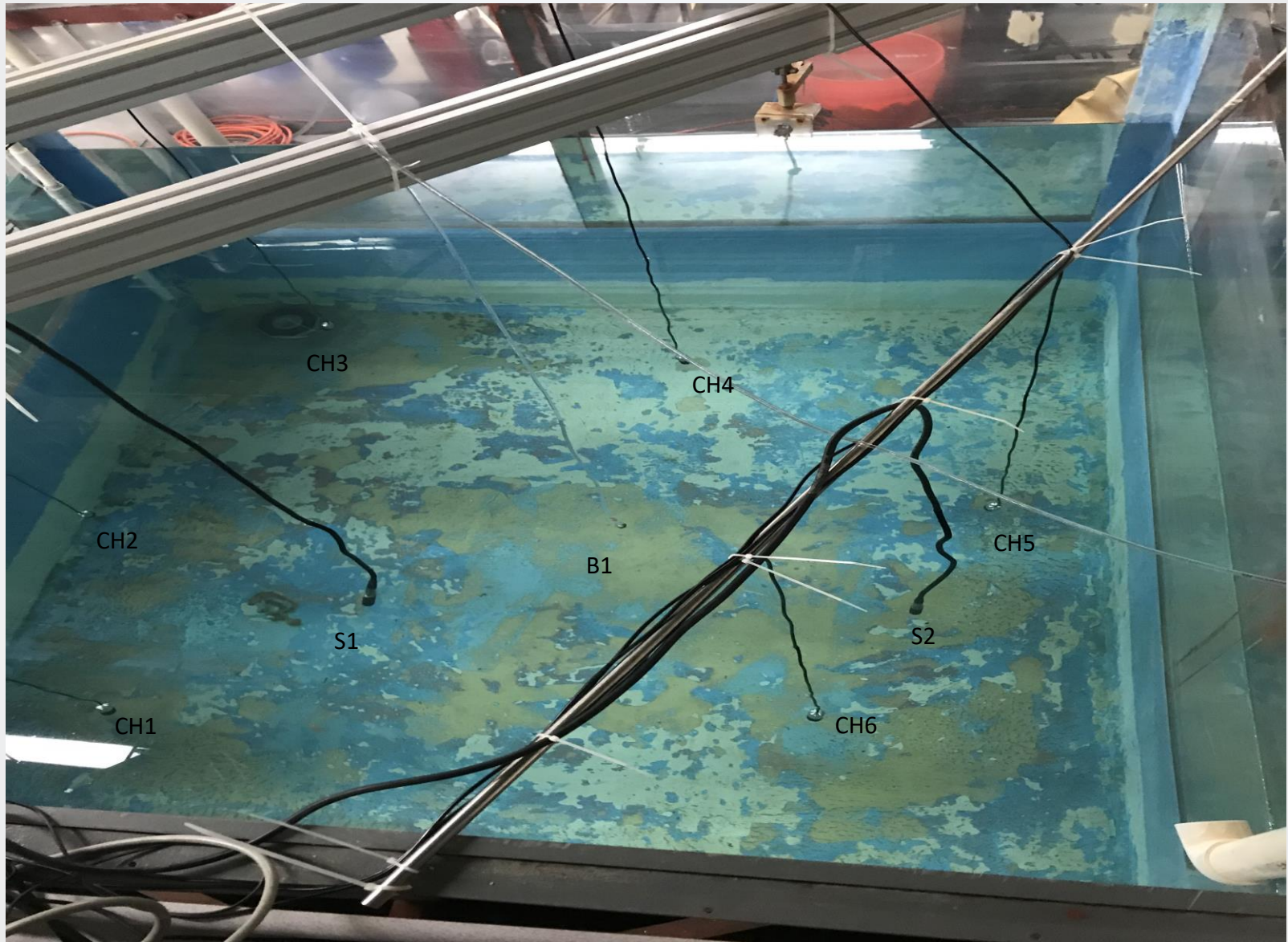
Early monitoring of the oil leakage from sound signals

Our work: Passive acoustic detection of oil leakage

Conduct laboratory experiments to model and study sound emitted from the leakage

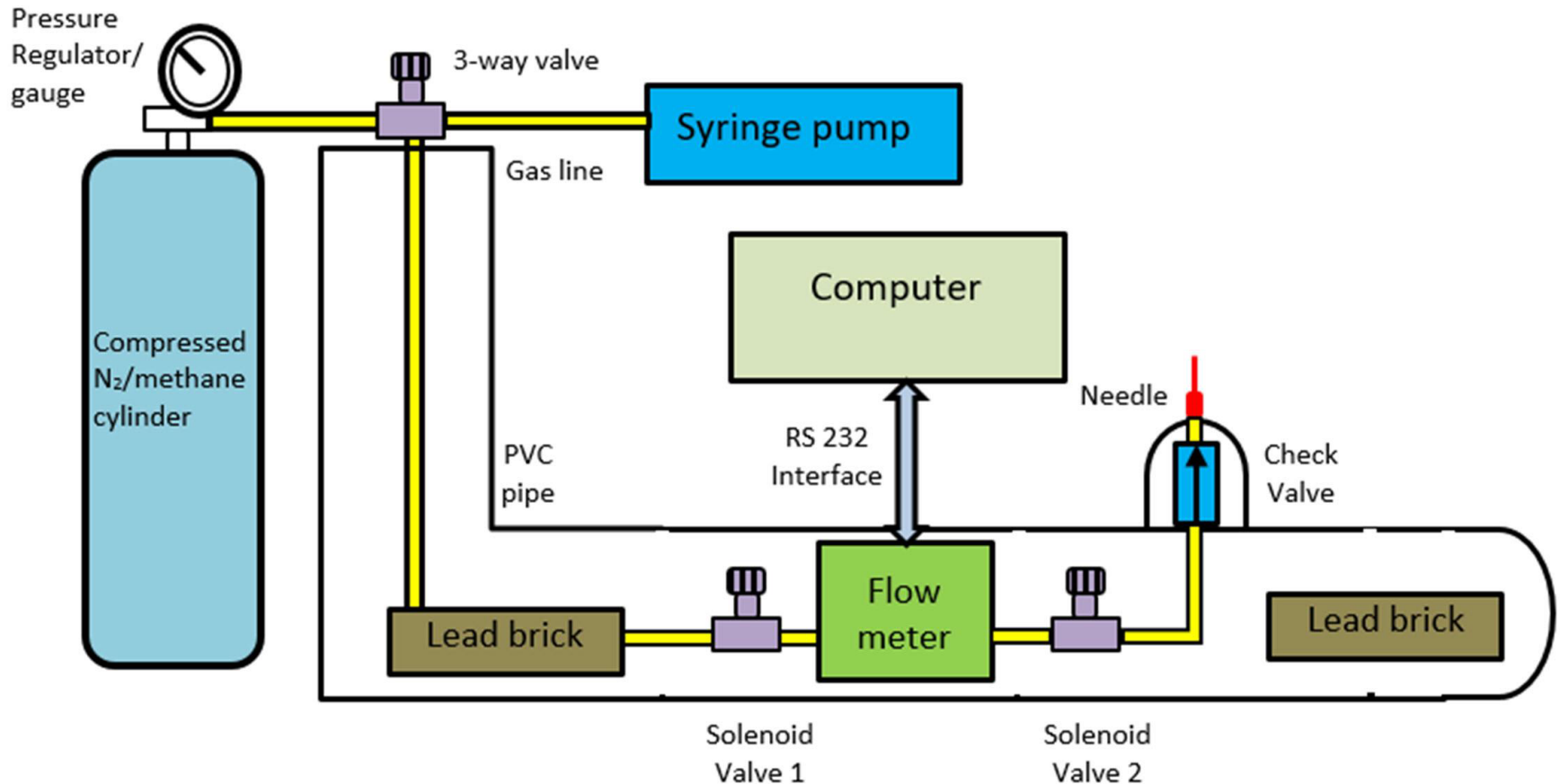


Hydrophone network for localization



Bubble generation

1. Flowrate of the gas
2. Needles with different diameters



Needle Diameters for Different Gauge

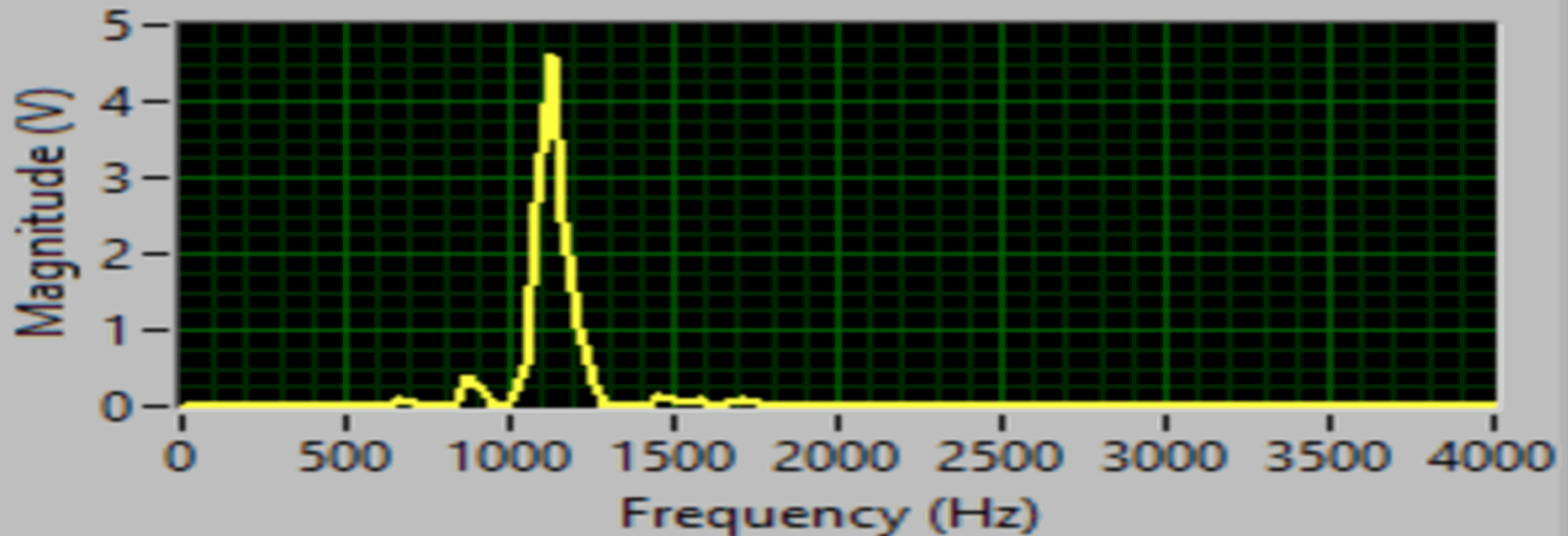
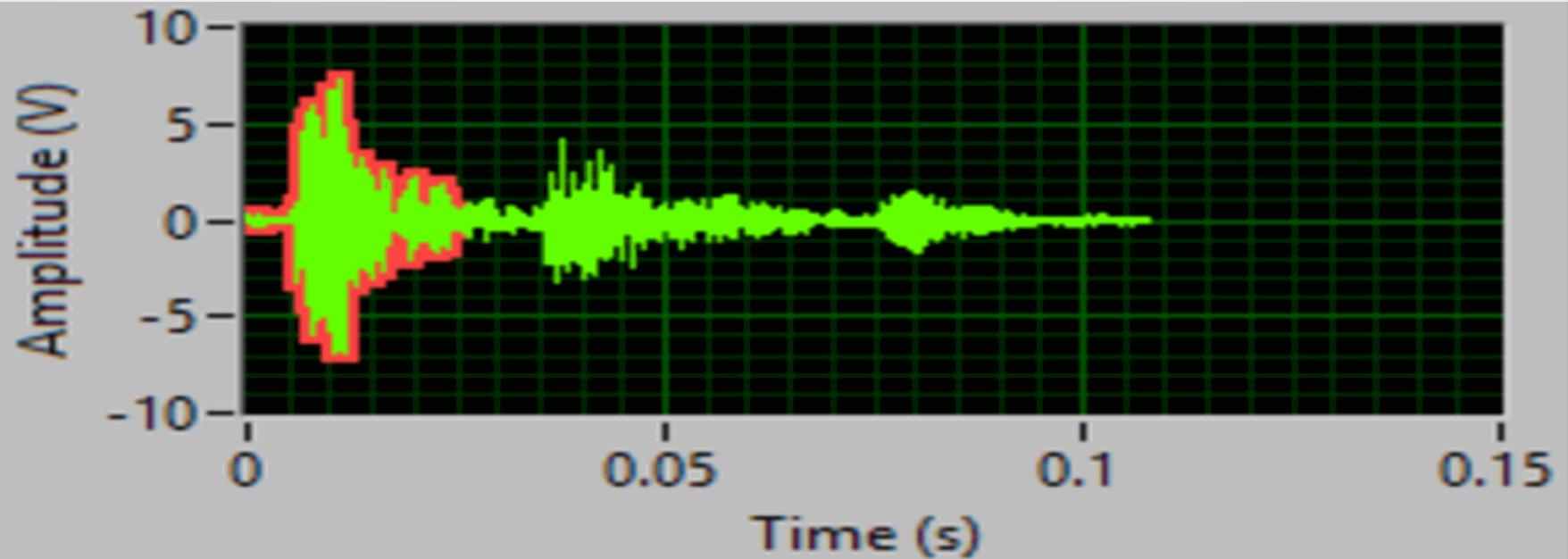
Gauge	diameter [mm]
12	2.16
14	1.6
16	1.19
18	0.84
20	0.6
22	0.41
24	0.31



A single bubble released from a nozzle (low flowrate)



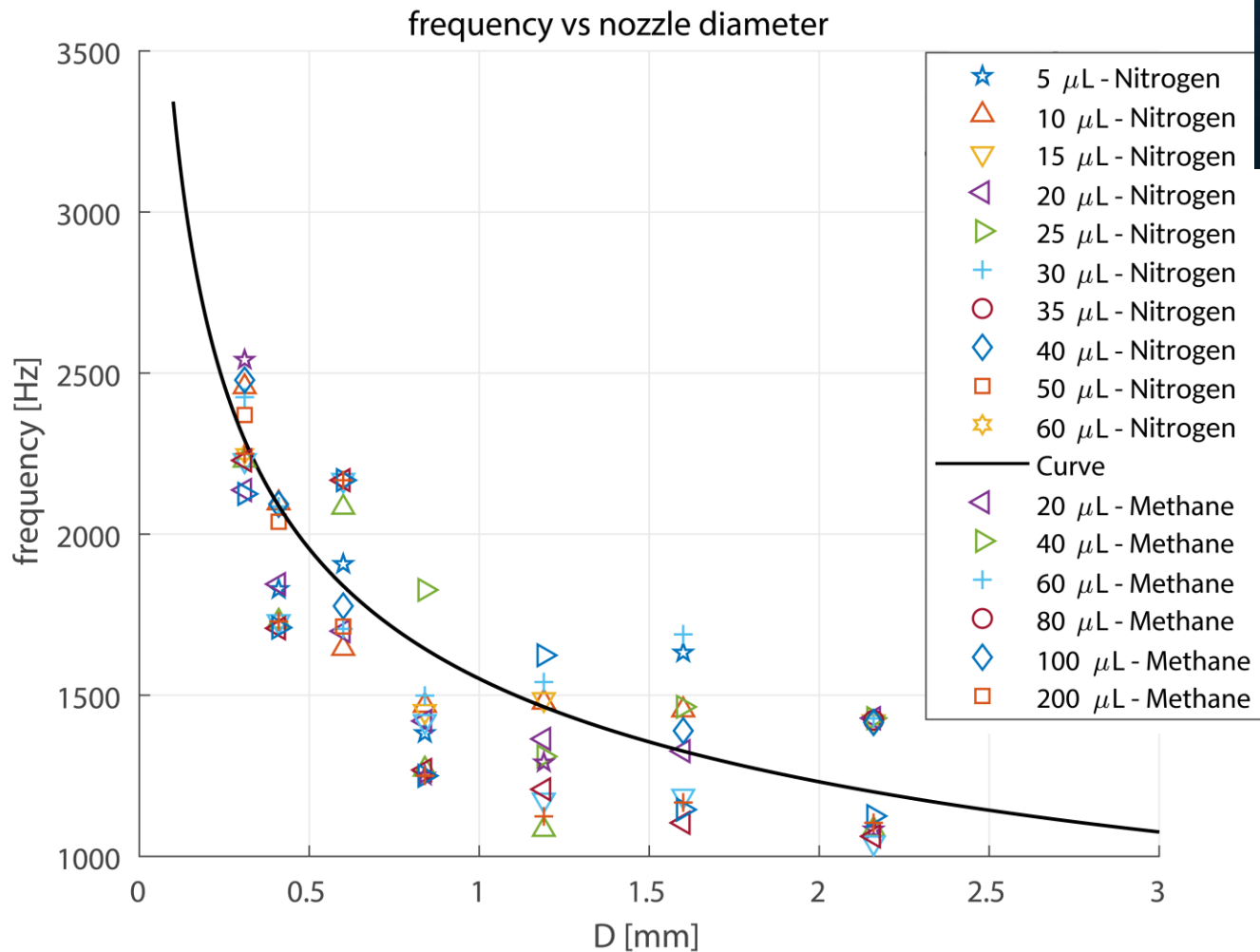
Sound signal and spectrum for a single bubble



Single bubble: central frequency vs diameter of needle

$$f \sim D^{-1/3}$$

J. Fluid Mech. (1991), vol. 230, pp. 365-390



$$f = \frac{1}{2\pi a} \left(\frac{3\gamma P}{\rho} \right)^{1/2}$$

f : the frequency

a : bubble radius

γ : gas constant

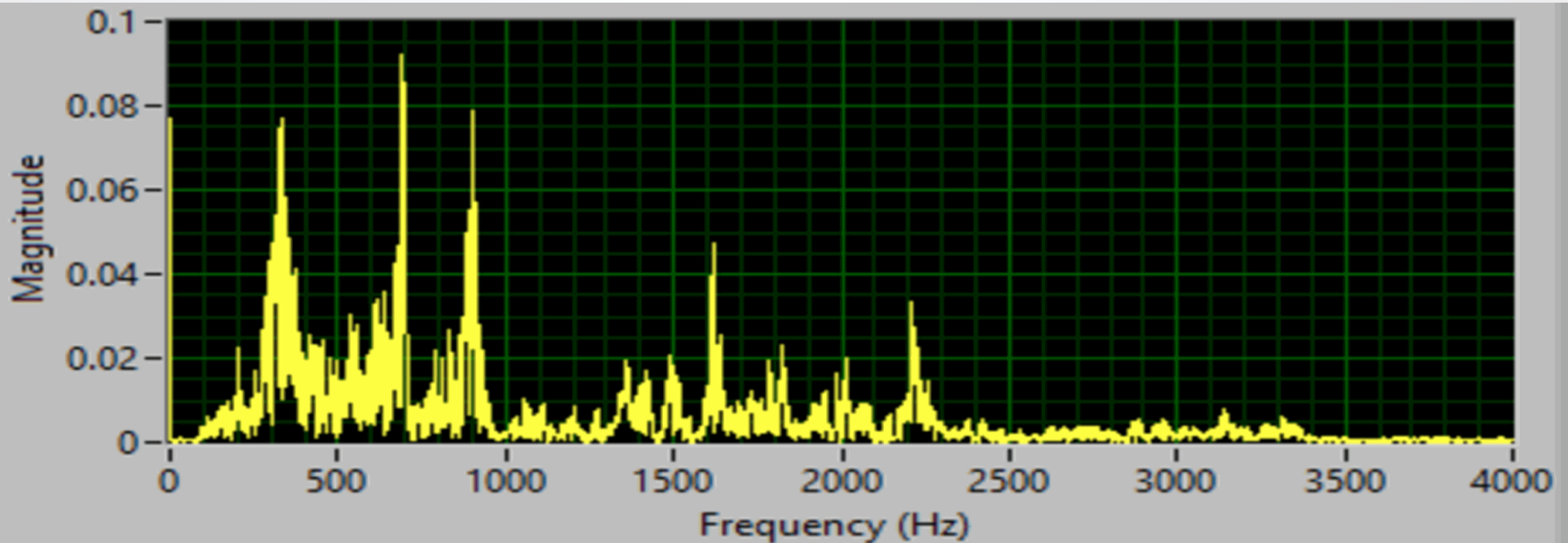
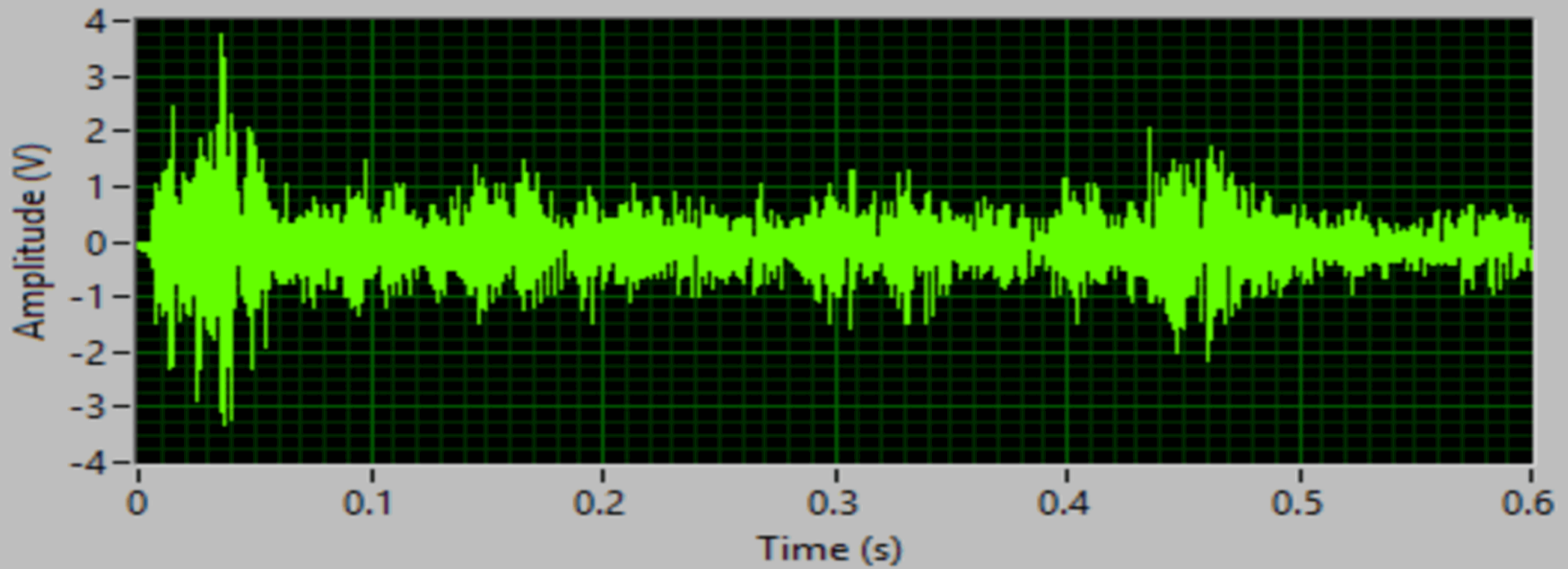
P : liquid pressure

ρ : liquid density

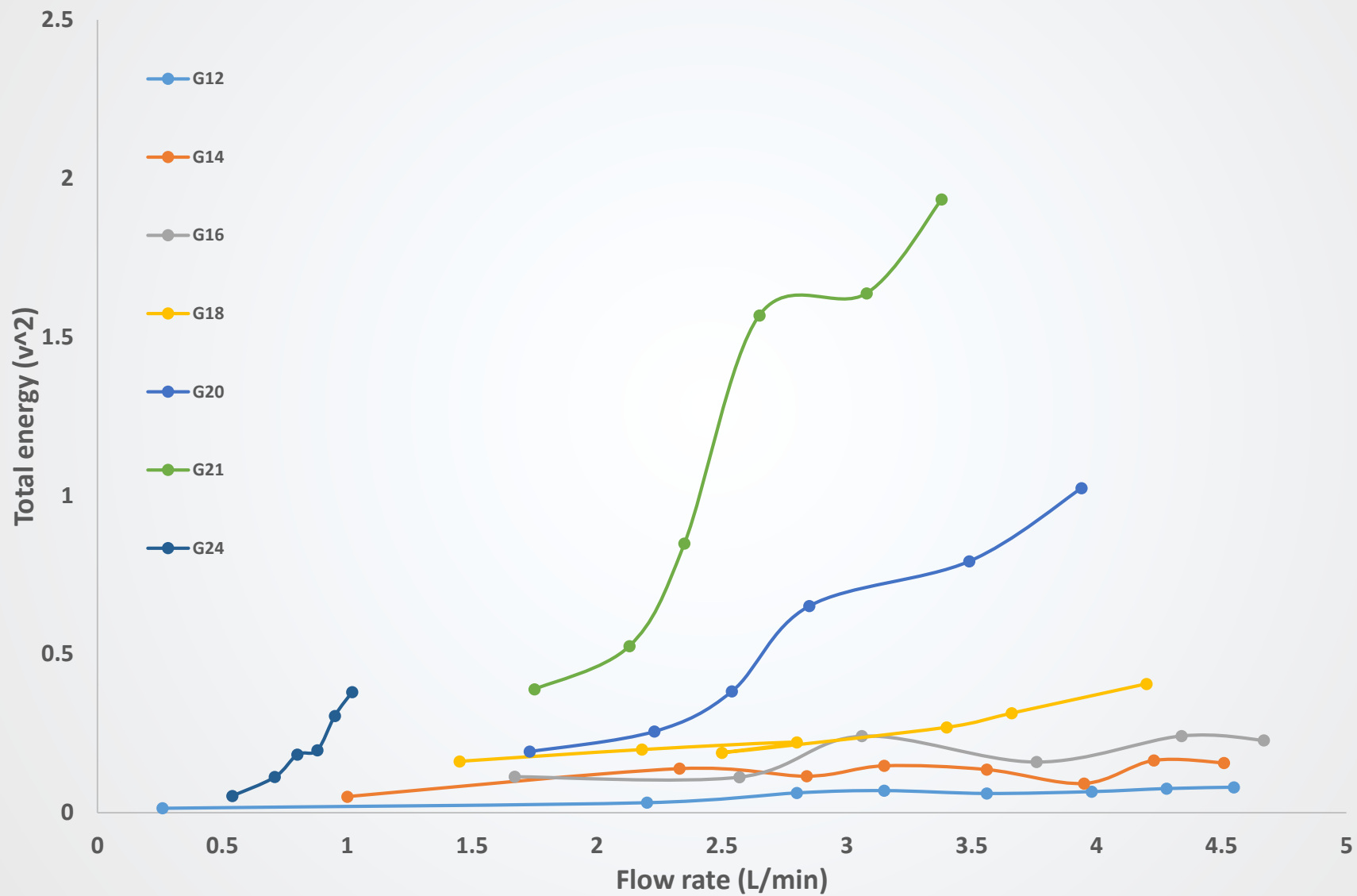
A cluster of bubbles released from a nozzle (high flowrate)



Sound signal and spectrum for a cluster of bubbles



Total Energy vs Flowrate

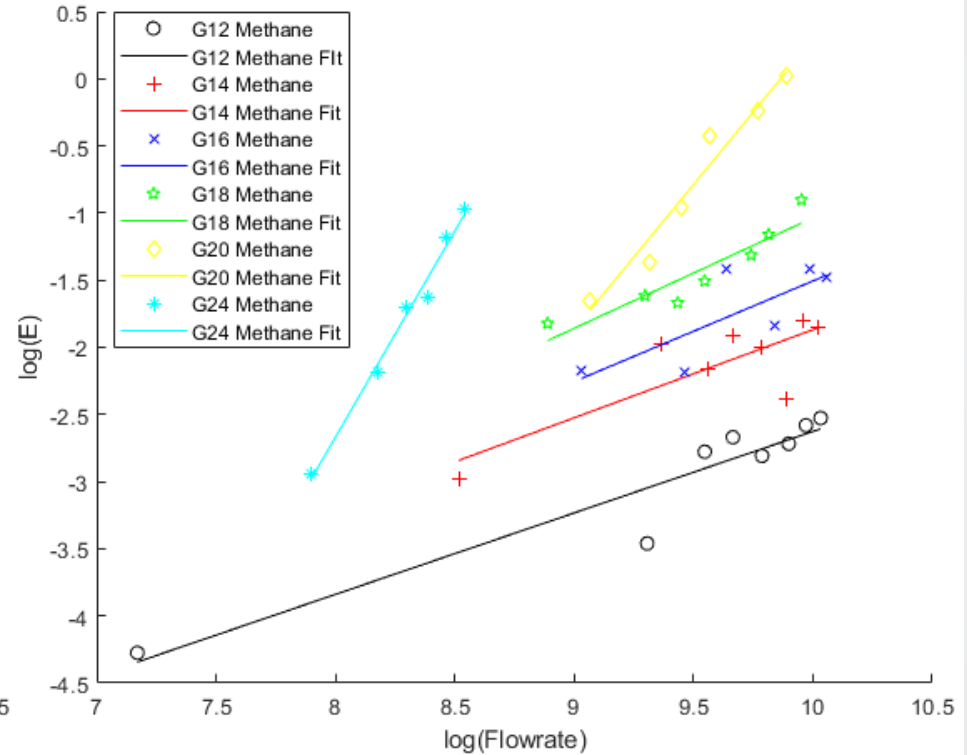
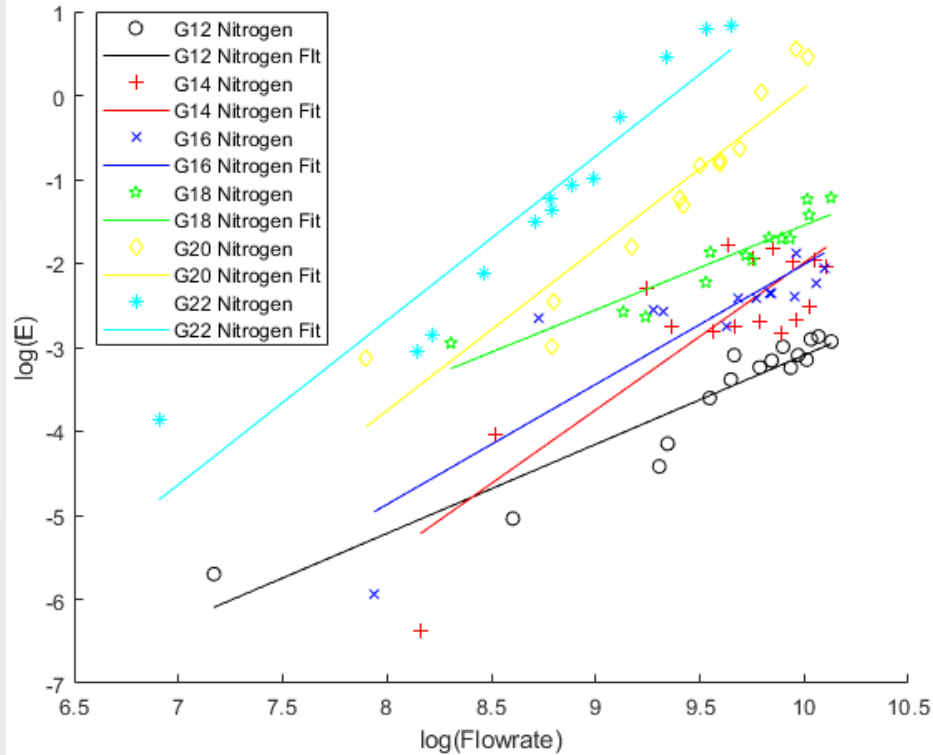


log(Total Energy) vs log(Flowrate)

Slope:

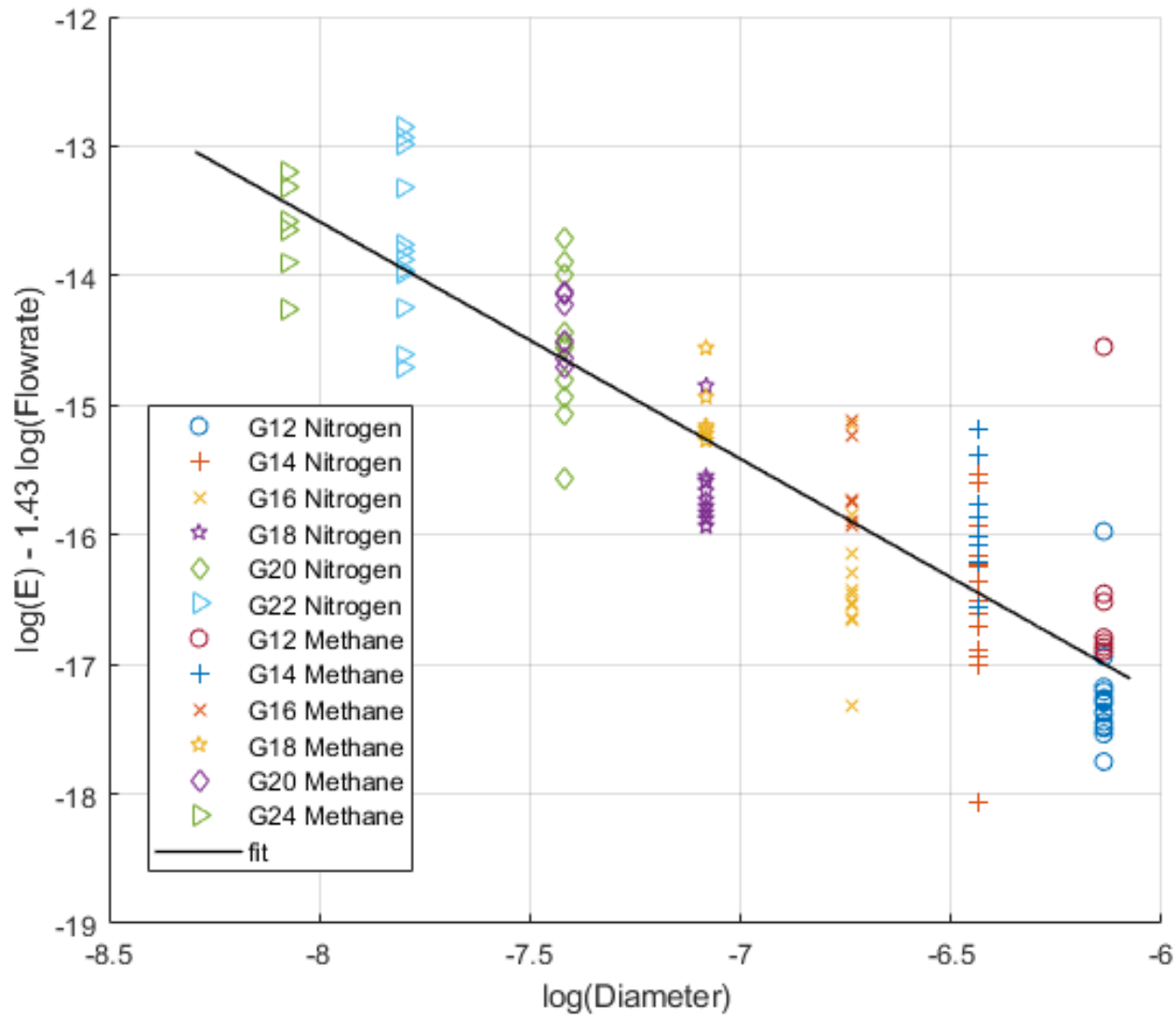
Mean value: 1.433

Standard deviation: 0.755

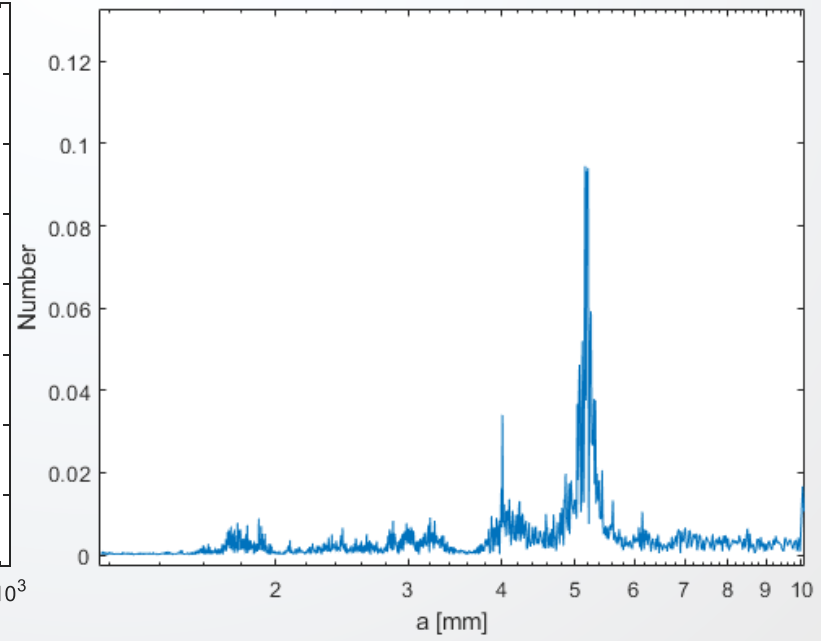
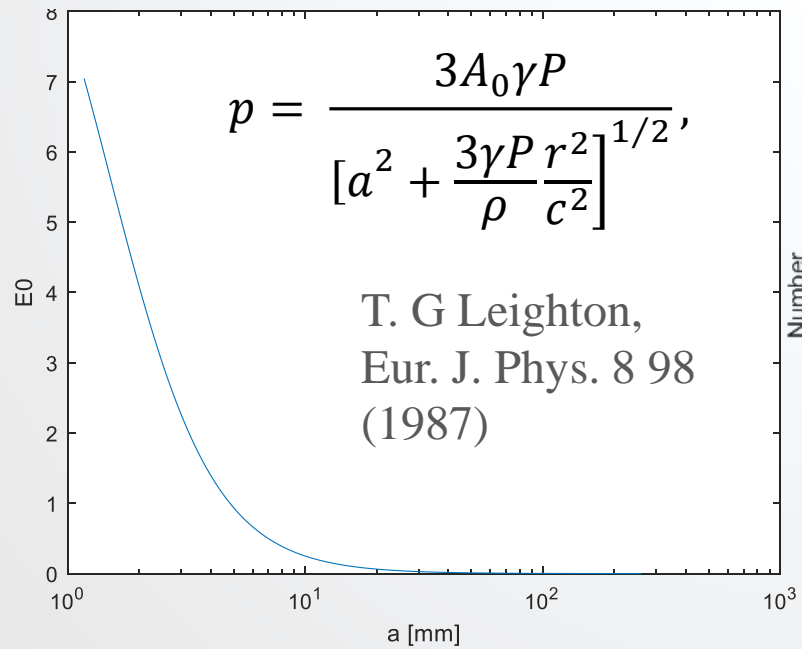
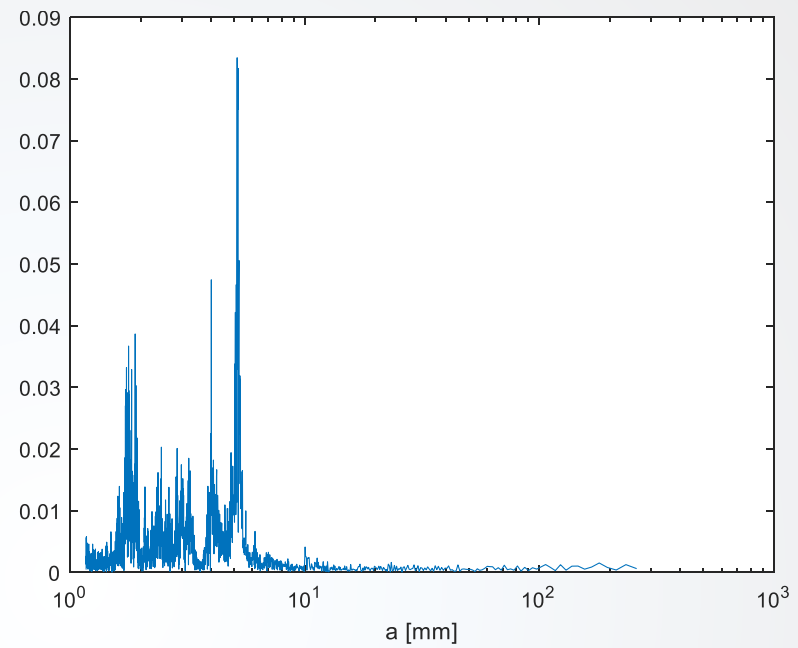
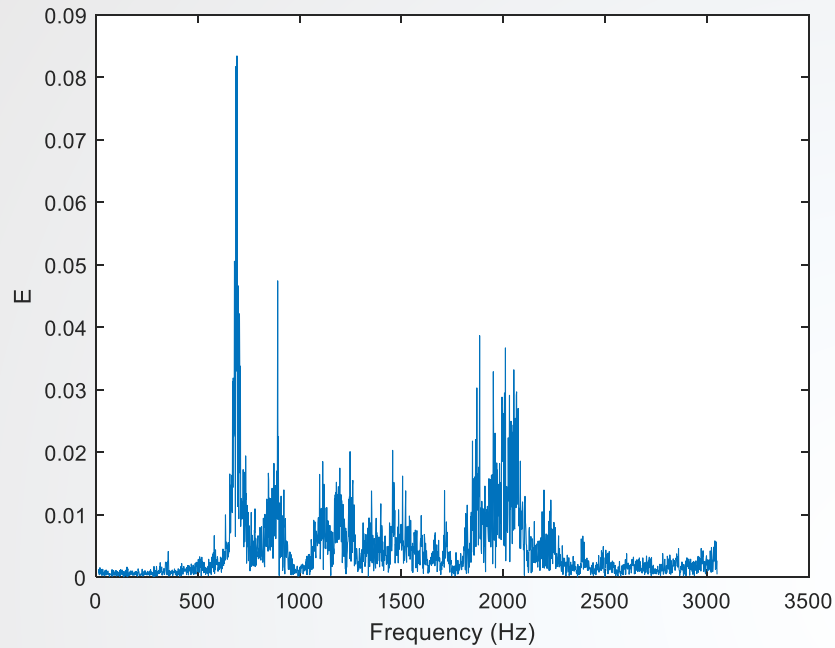


$\log(E)$ vs $\log(\text{Diameter})$

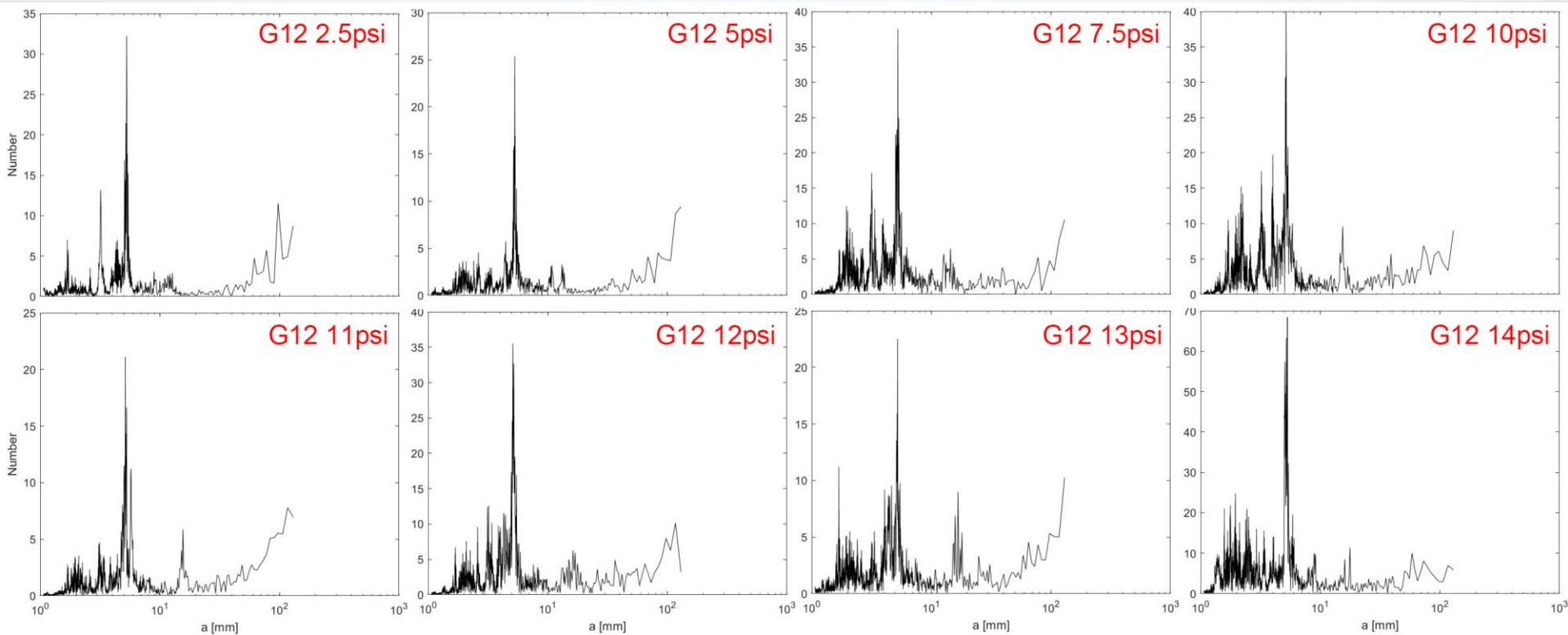
Slope: -1.8324



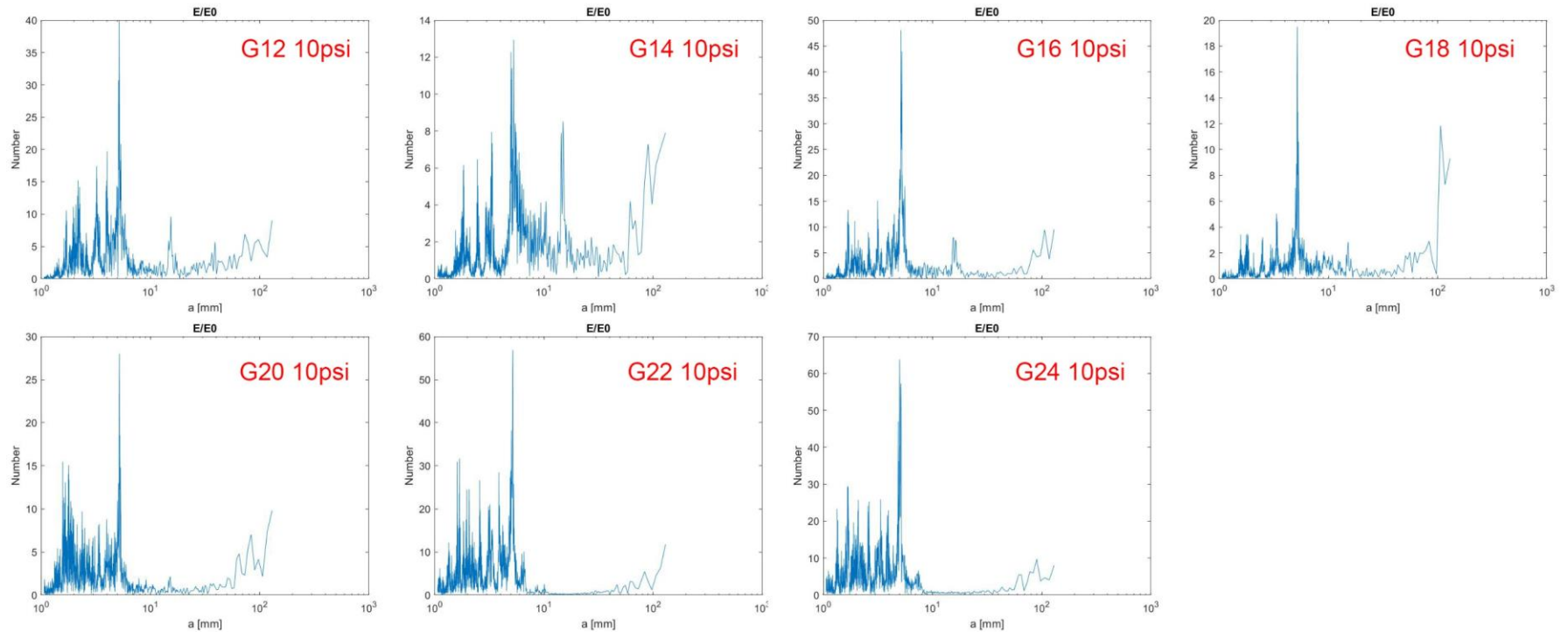
Bubble distribution



Keep Diameter Change Flowrate



Change Diameter Keep Flowrate



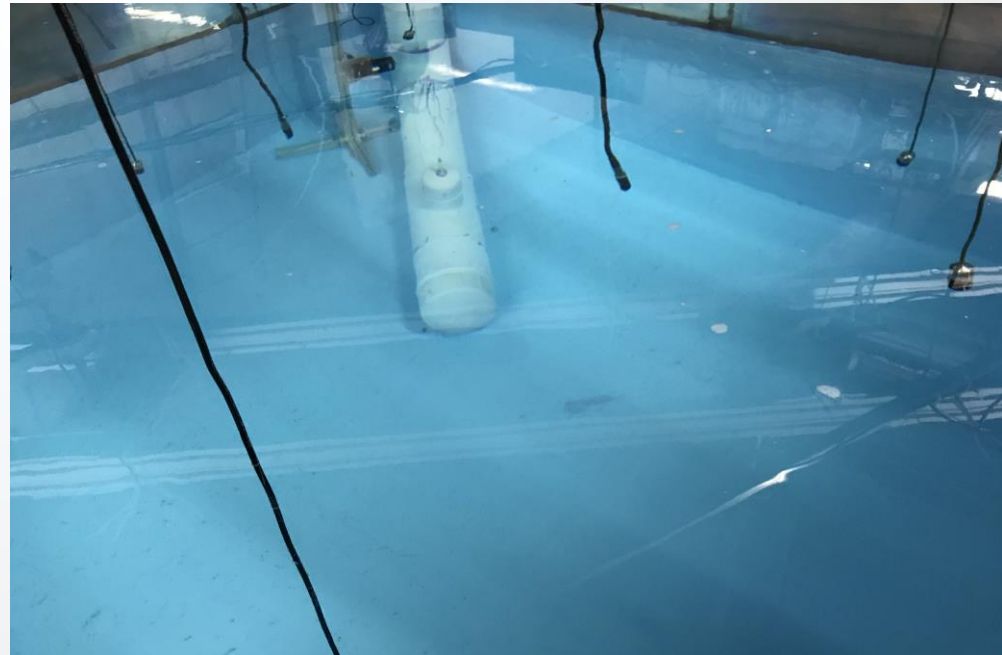
Summary

1. Low flowrate: we found the relation between **central frequency** and the **diameters** of the needle.

$$f \sim D^{-1/3}$$

2. High flowrate: we found the relation between **total energy** and the **diameters** of the needle.

3. Bubble size distribution



Thank you!

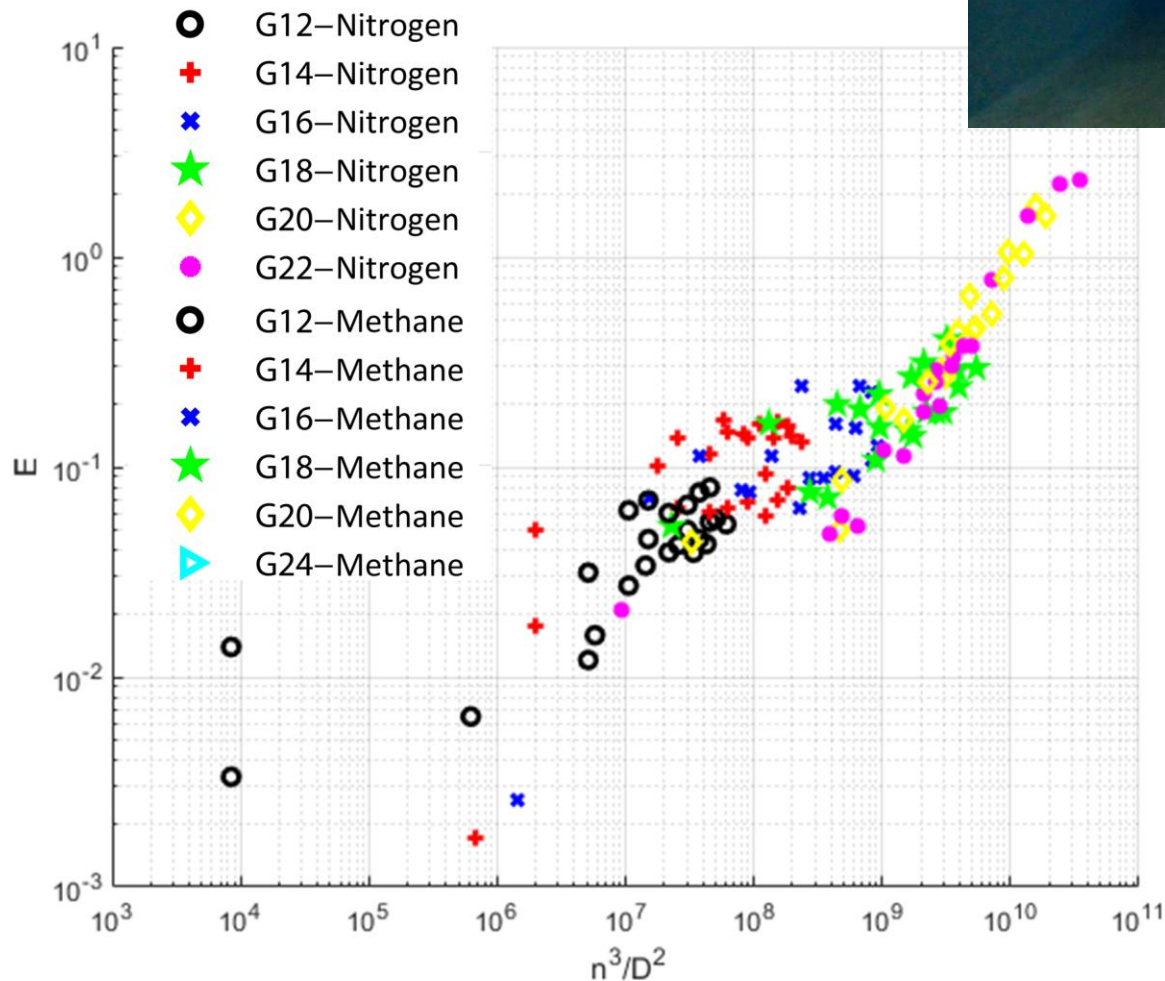
Acknowledgment

Funding from Gulf Research Program of the National Academy of Sciences with award number: 2000008860.

A cluster of bubbles (Constant flowrate)

$$n = \frac{\text{FlowRate} \times \text{time}}{\text{Single bubble volume}}$$

$$E \sim \frac{n^3}{D^2} \text{ in log scale}$$



Single bubble volume
can be found in
*J. Fluid Mech. (1991),
vol. 230, pp. 365-390*

Problem and Motivations: Pollutions

Oil spills can cause a lot of effects:

The short-term effects would be **mammals**, **fish** and **birds** ingesting them;

The long-term effects would be **accumulation** of oil through food chain which can lead to **ecological imbalance** and **extinction of several species**.

Source: google image



Problem and Motivations: Pollutions

Oil spills spread rapidly. Once the oil expands to a wide area extraction is **difficult** and **expensive**.

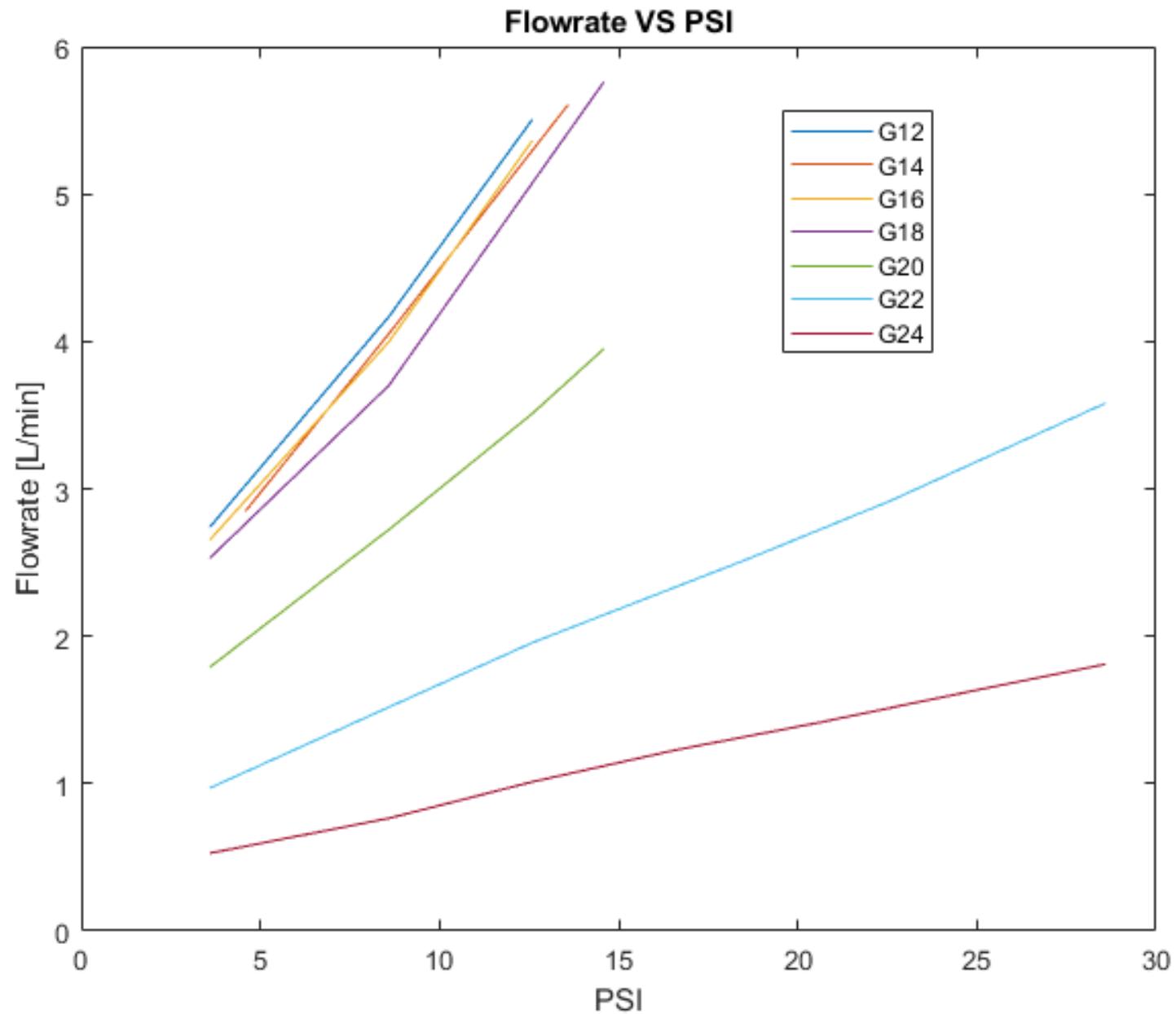
For this reason, detecting oil spill source location and **characterize the oil leakage from the recorded sound signals** are very important.

In order to get some data for the characterization, we performed some laboratory experiments.



Source: google image

Flowrate vs Pressure for Different Needles



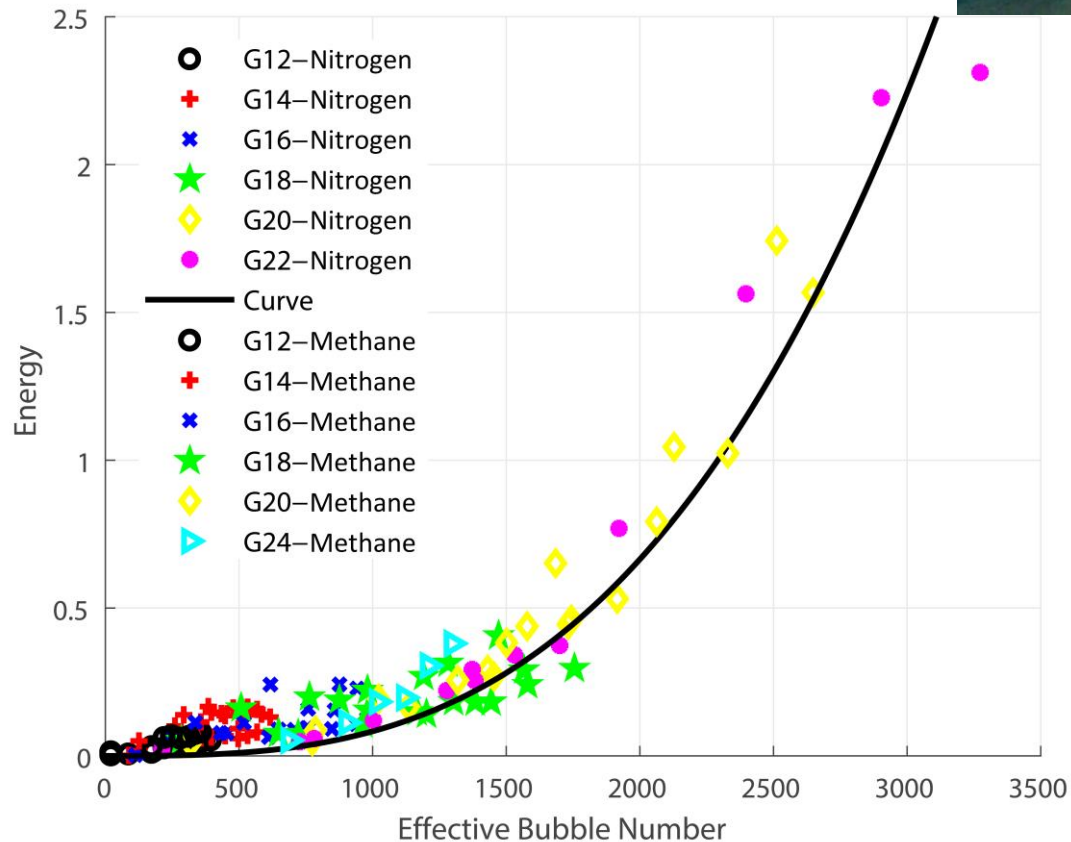
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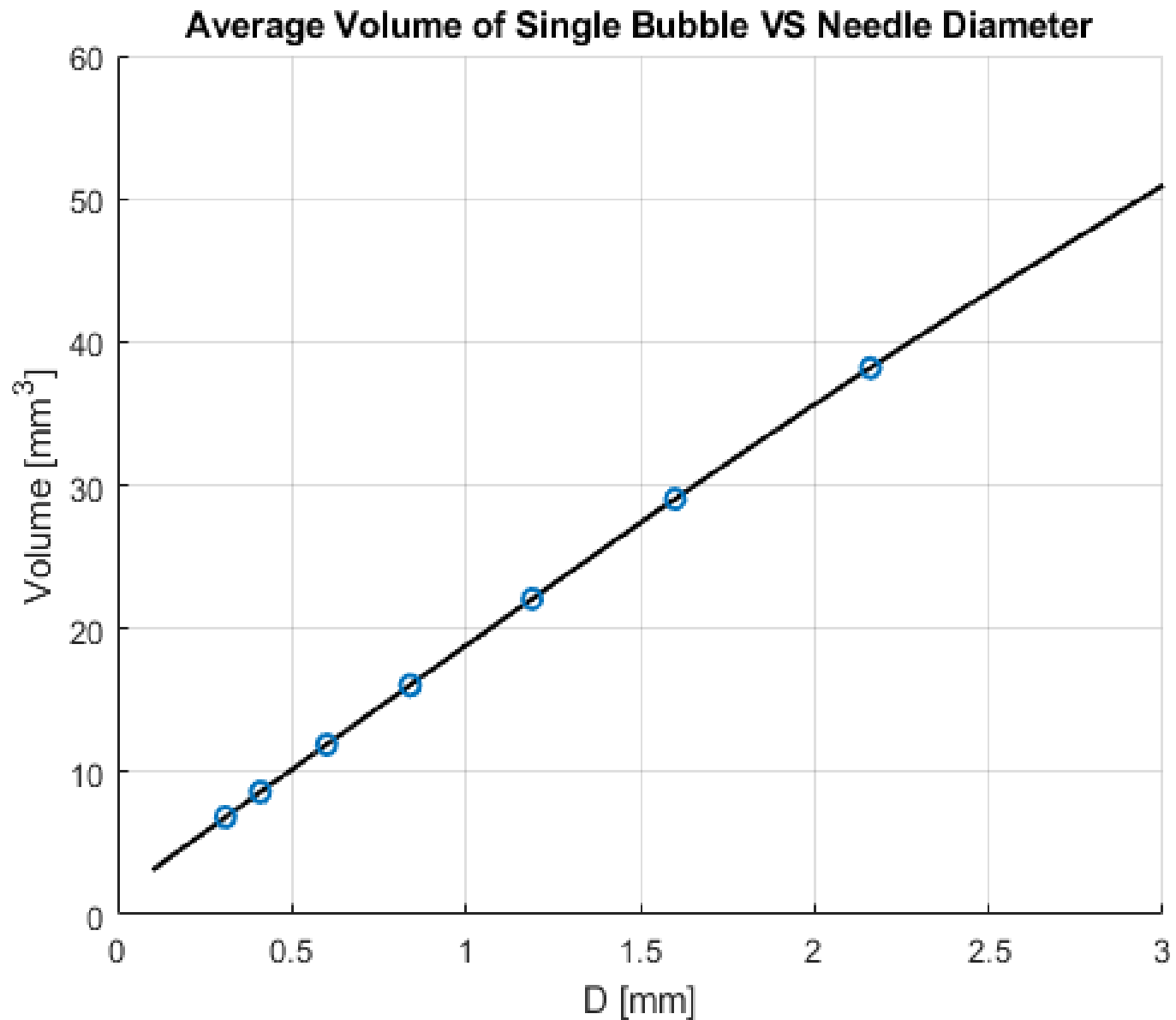
A cluster of bubbles (Constant flowrate)

$$n = \frac{\text{FlowRate} \times \text{time}}{\text{Single bubble volume}}$$

$$E = \frac{A}{D^2} n^3$$

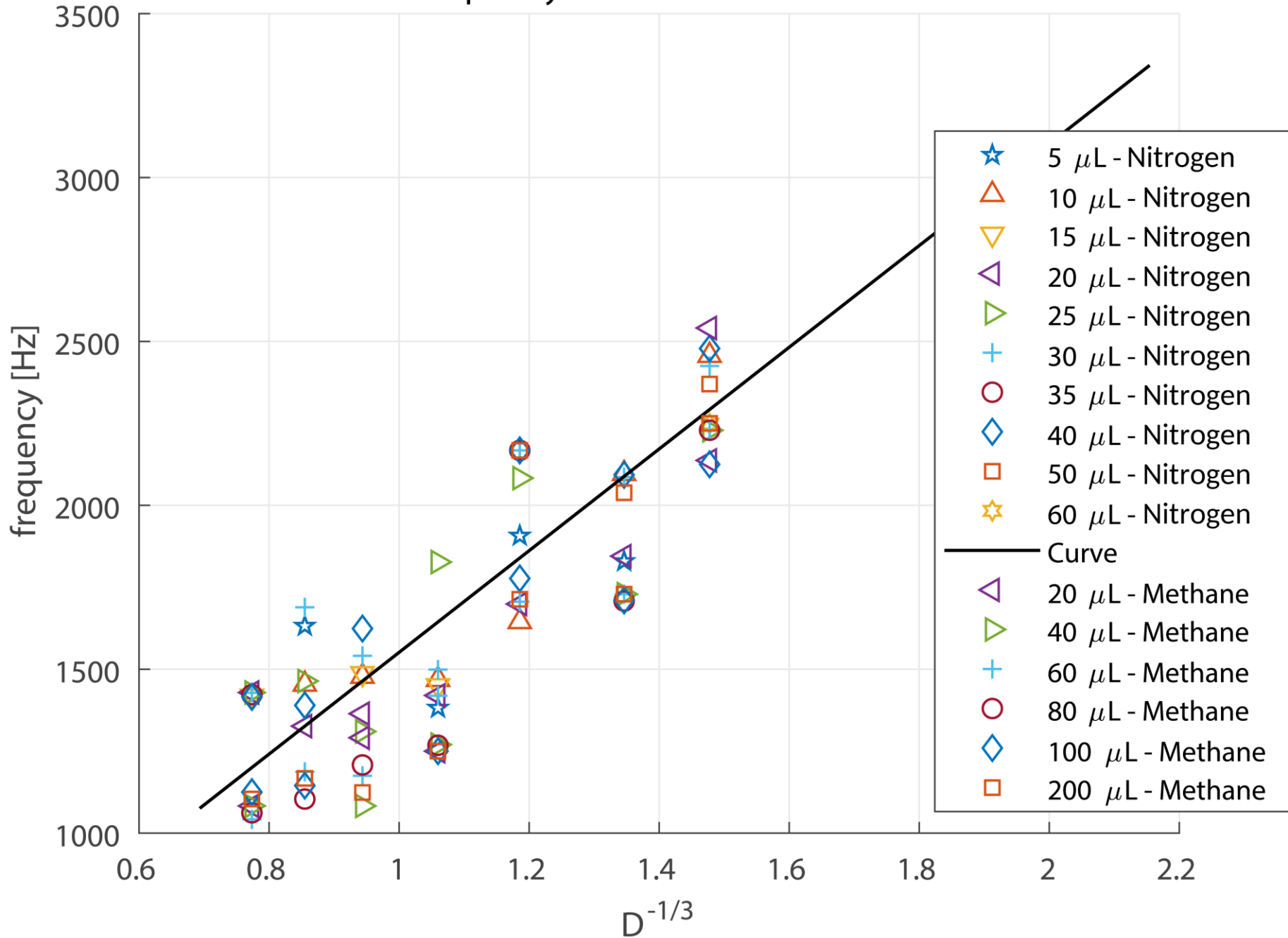


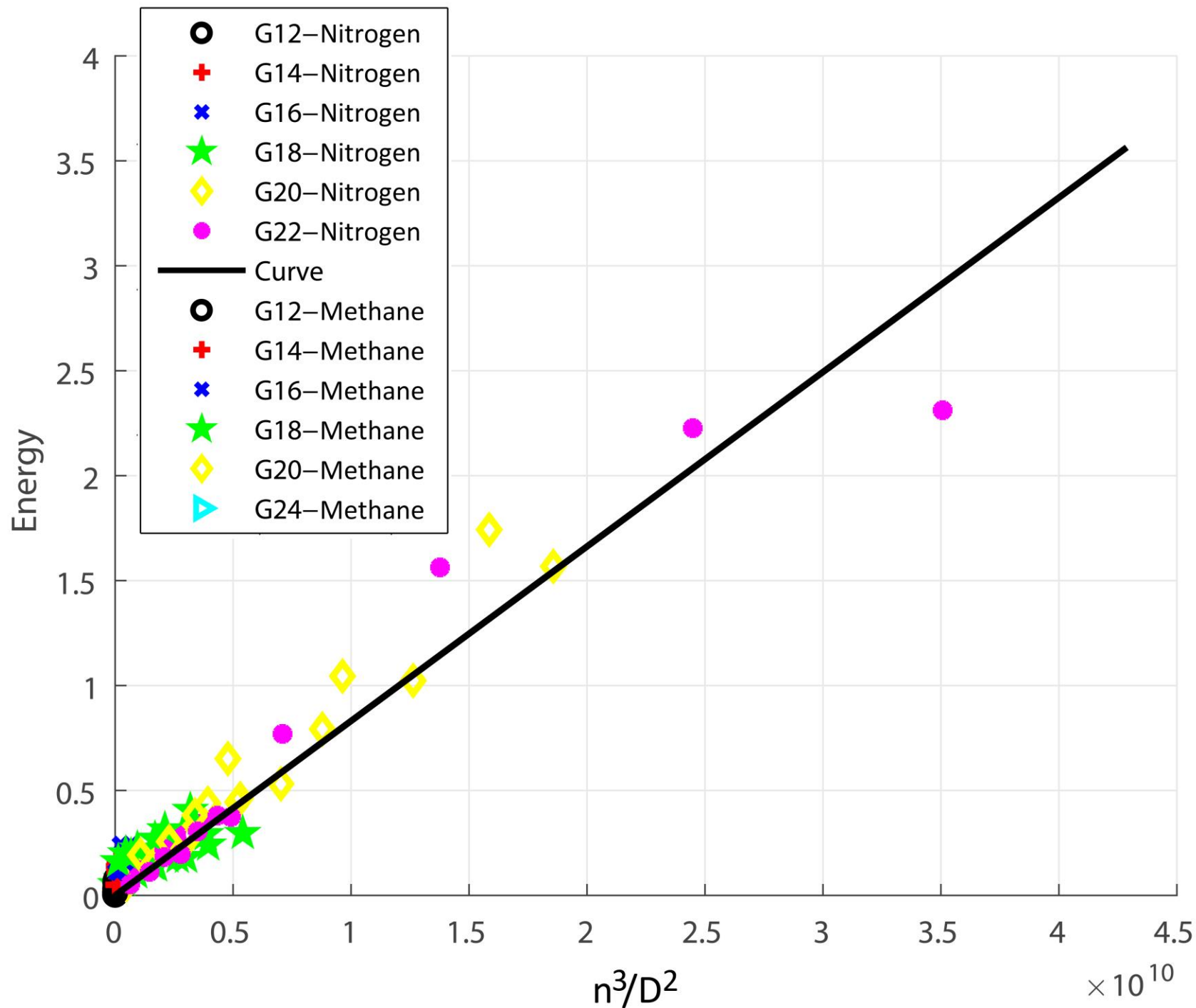
*Single bubble volume
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Mech. (1991), vol. 230,
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Data from *J. Fluid Mech.* (1991), vol. 230, pp. 365-390

frequency vs nozzle diameter





Summary

1. Low flowrate: we found the relation between **central frequency** and the **diameters** of the needle.

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2. High flowrate: we found the relation between **total energy** and the **diameters** of the needle.

$$n = \frac{\textit{FlowRate} \times \textit{time}}{\textit{Single bubble volume}}$$

$$E = \frac{A}{D^2} n^3$$

3. Bubble size distribution