Characterization of sound induced by bubbles released from nozzles

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(Preliminary results)

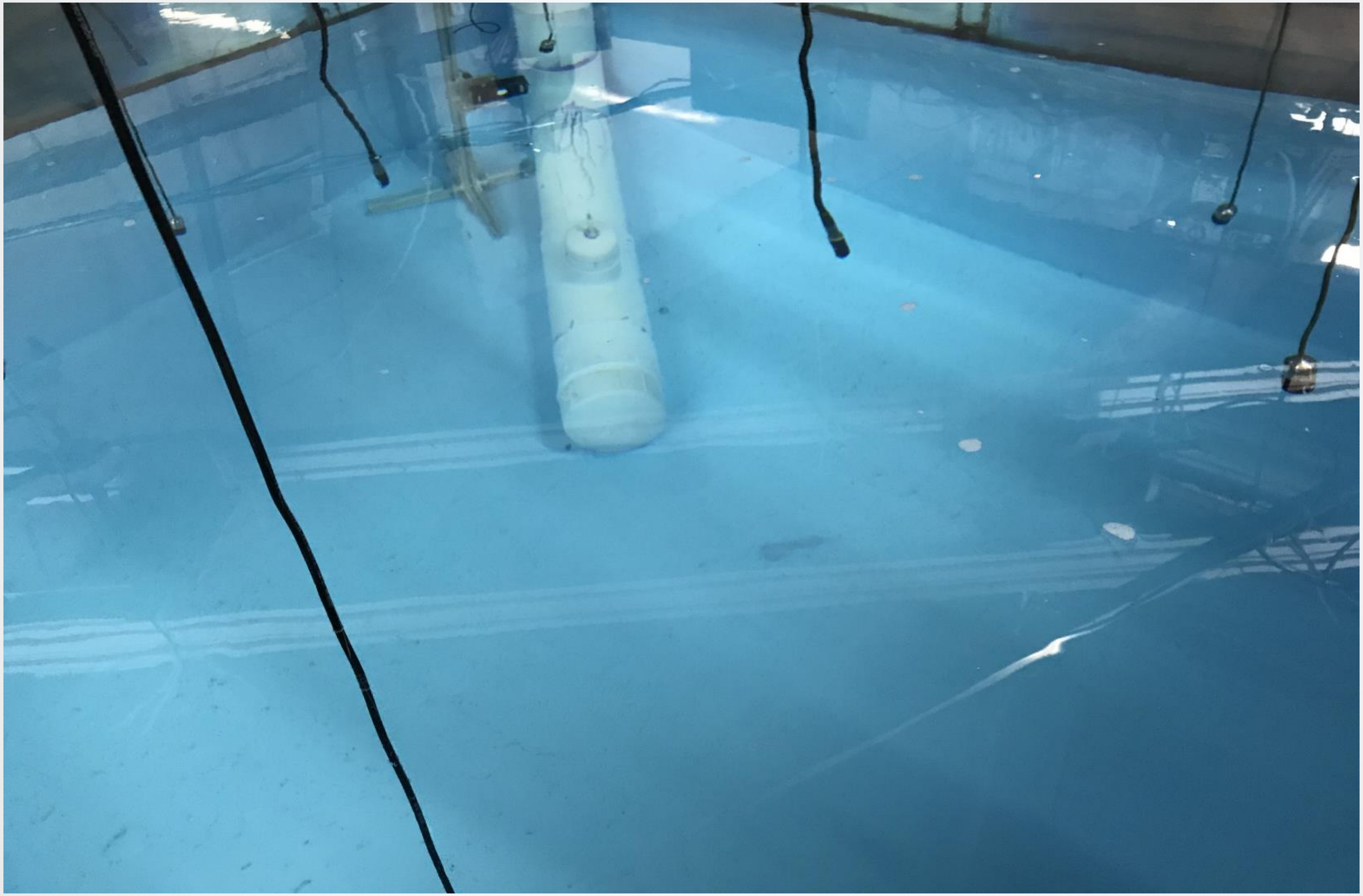
Funding from Gulf Research Program of the National Academy of Sciences

Problem and Motivations: Oil leakage

Early monitoring of the oil leakage from sound signals

Our work: Passive acoustic detection of oil leakage

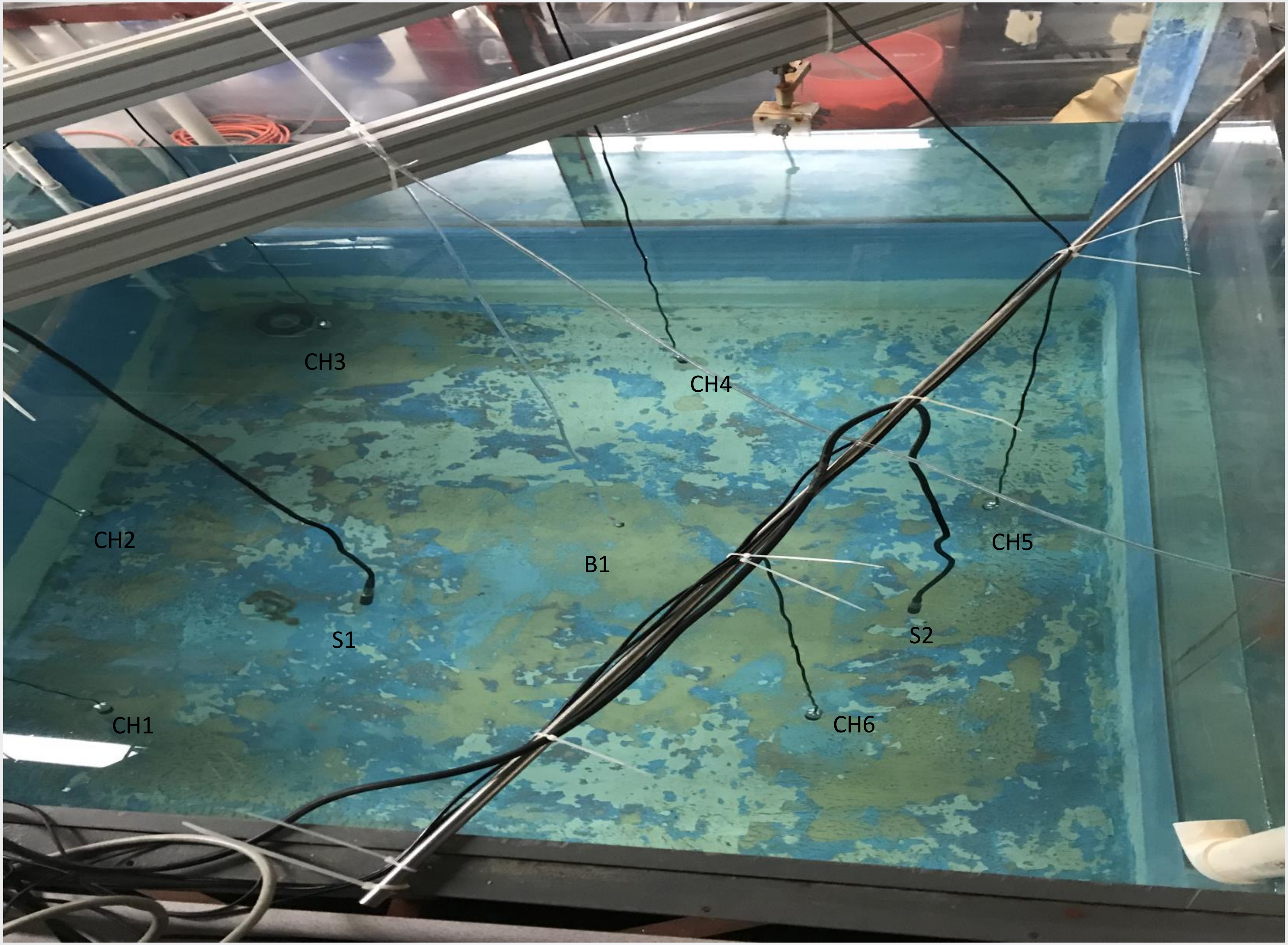
Conduct laboratory experiments to model and study sound emitted from the leakage



8′

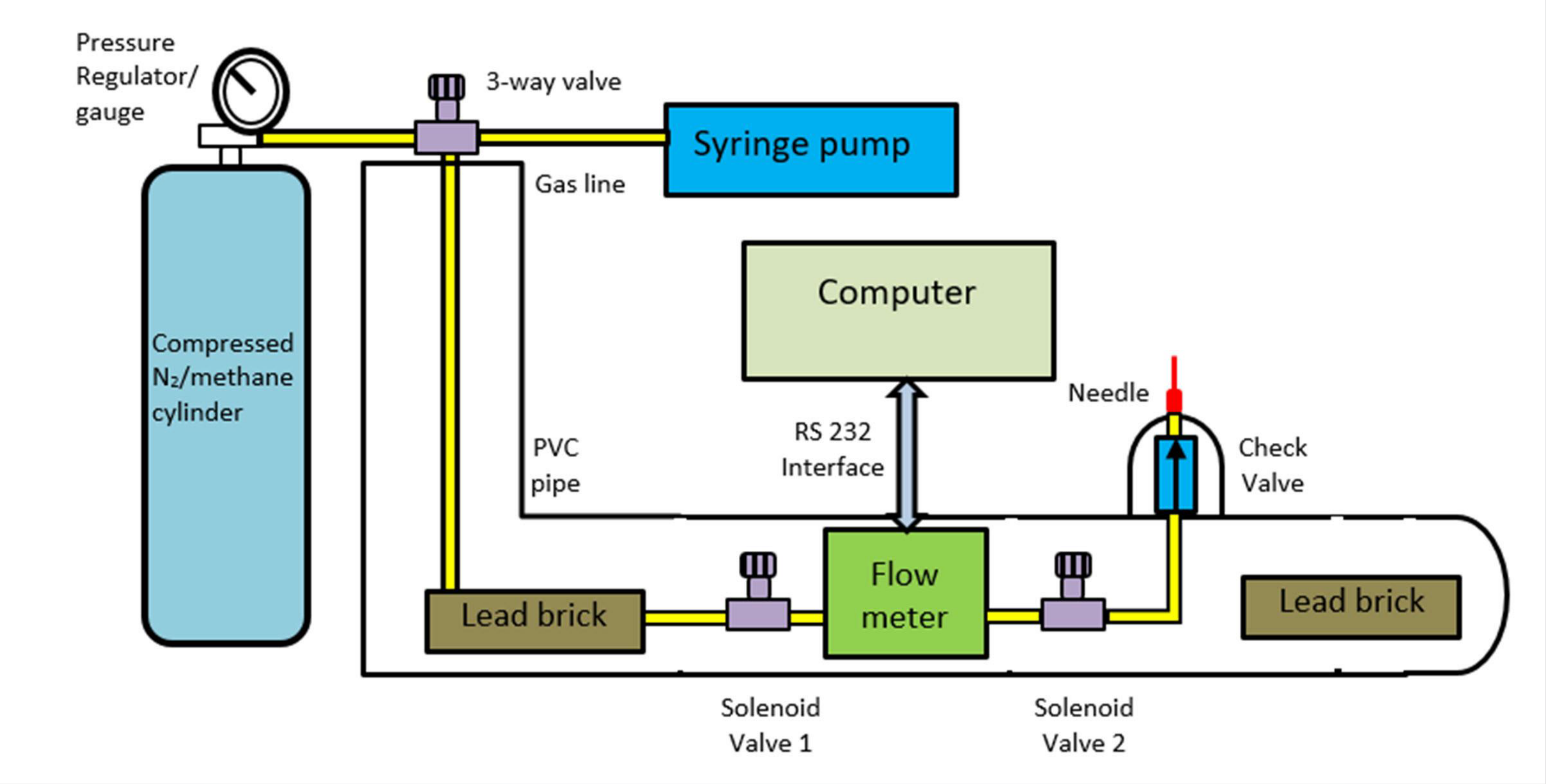
8′

Hydrophone network for localization



Bubble generation

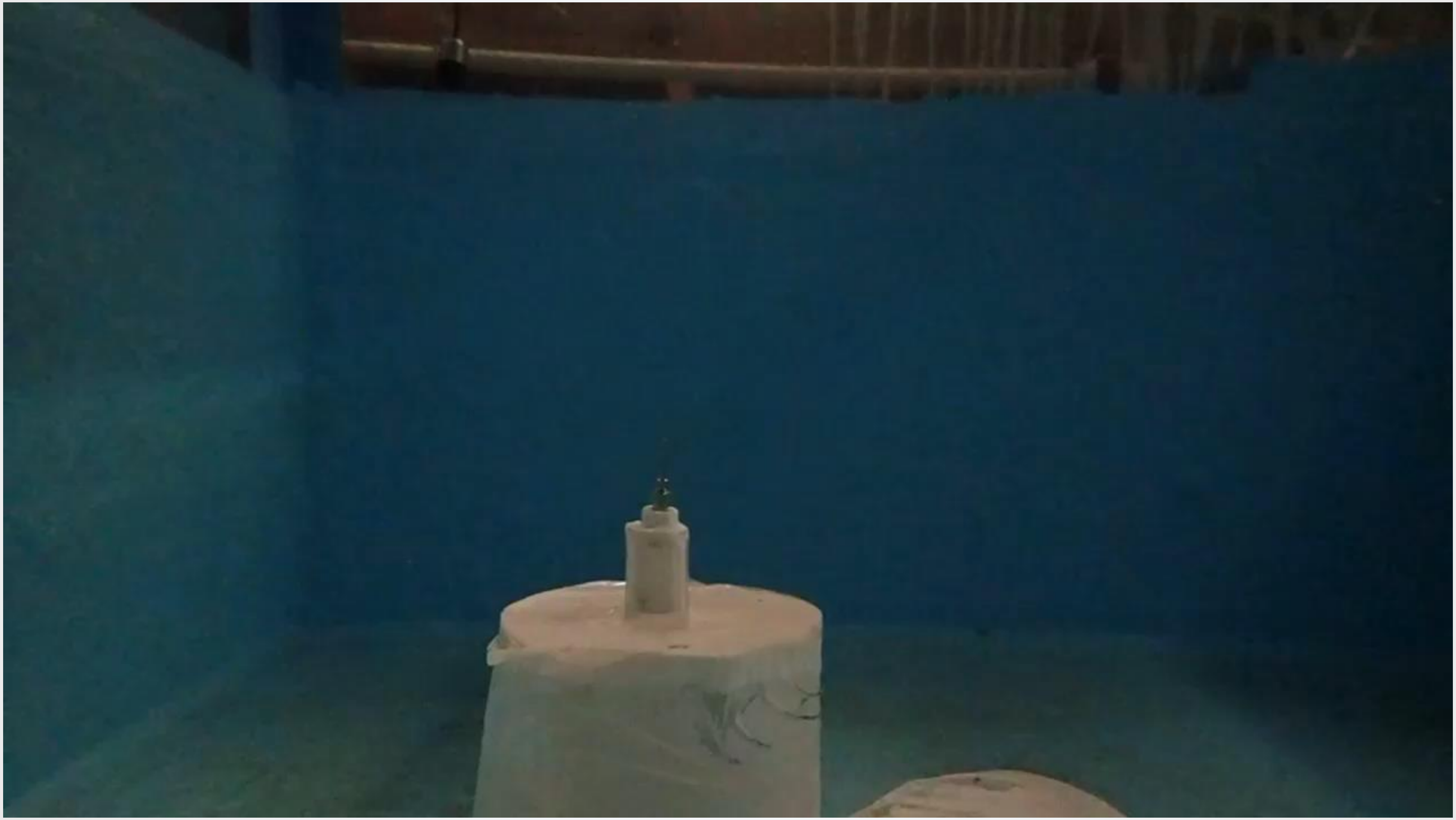
1. Flowrate of the gas
2. Needles with different diameters



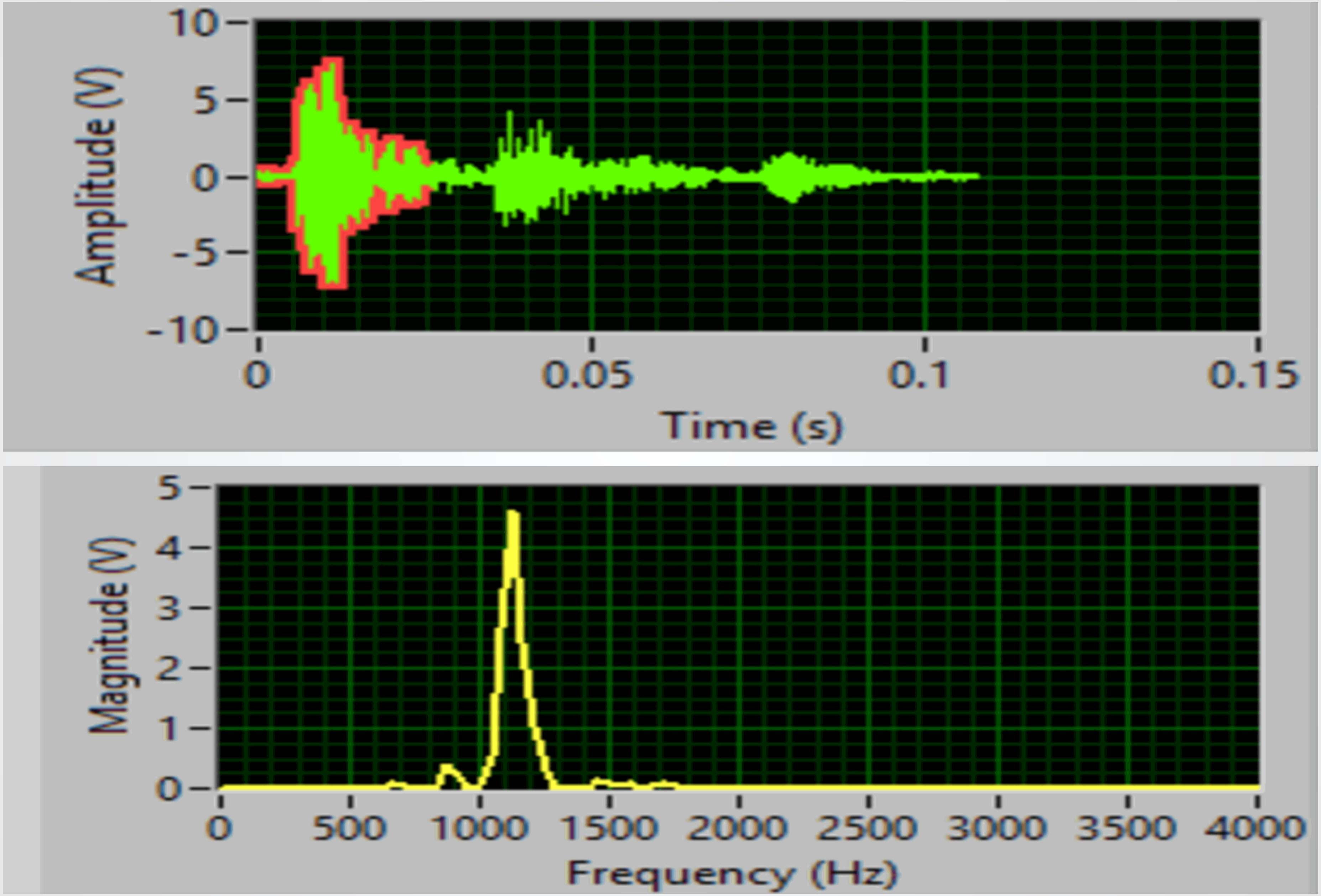
Needle Diameters for Different Gauge

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)



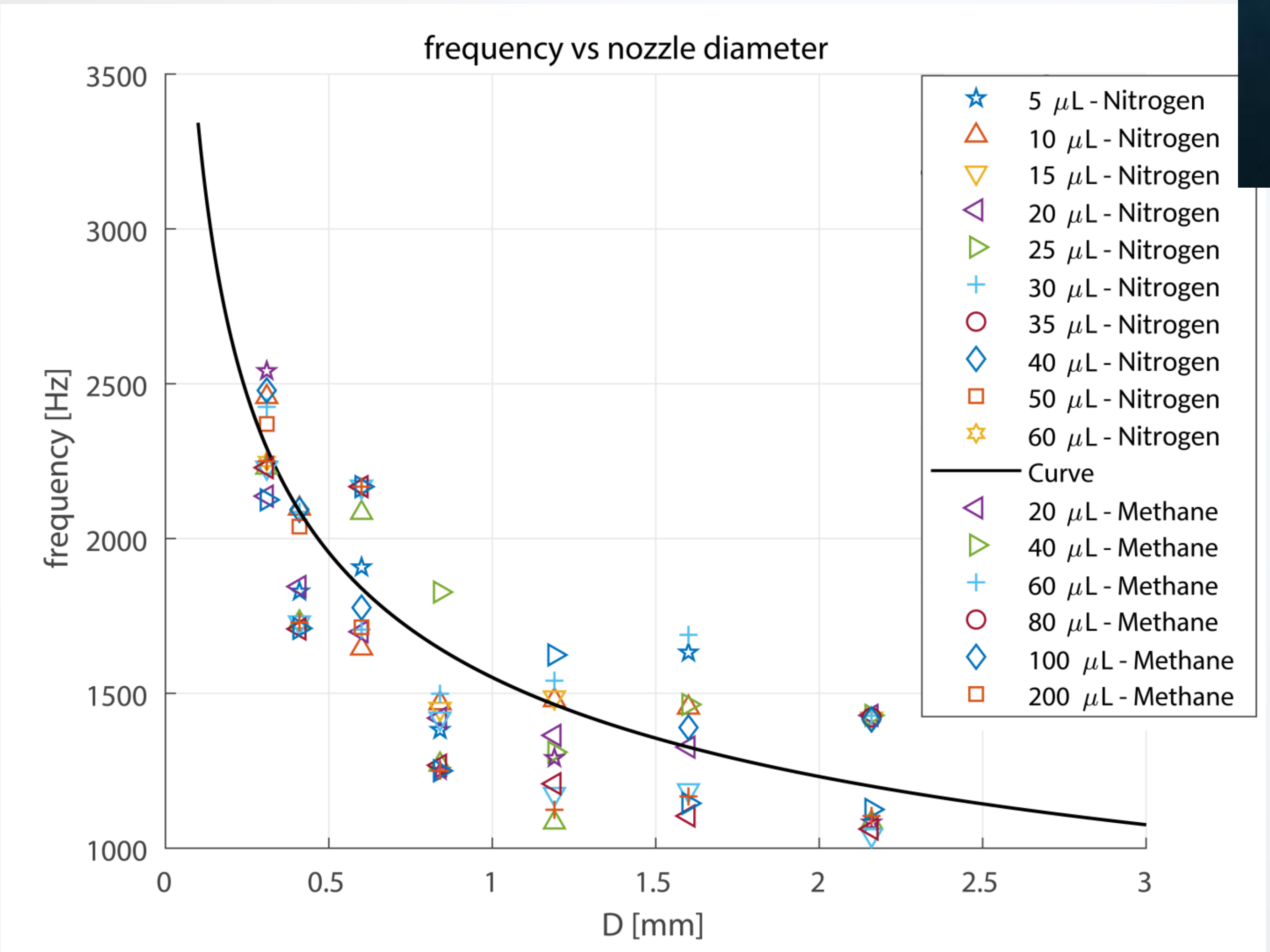
Sound signal and spectrum for a single bubble



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

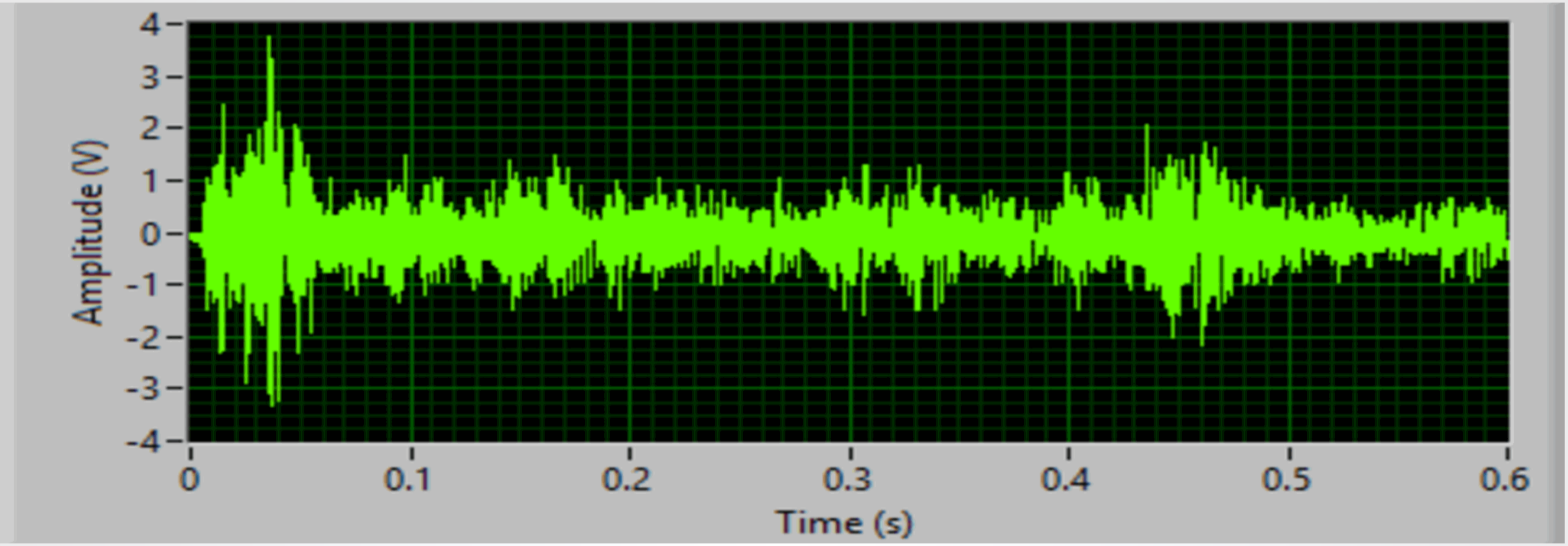
γ: gas constant

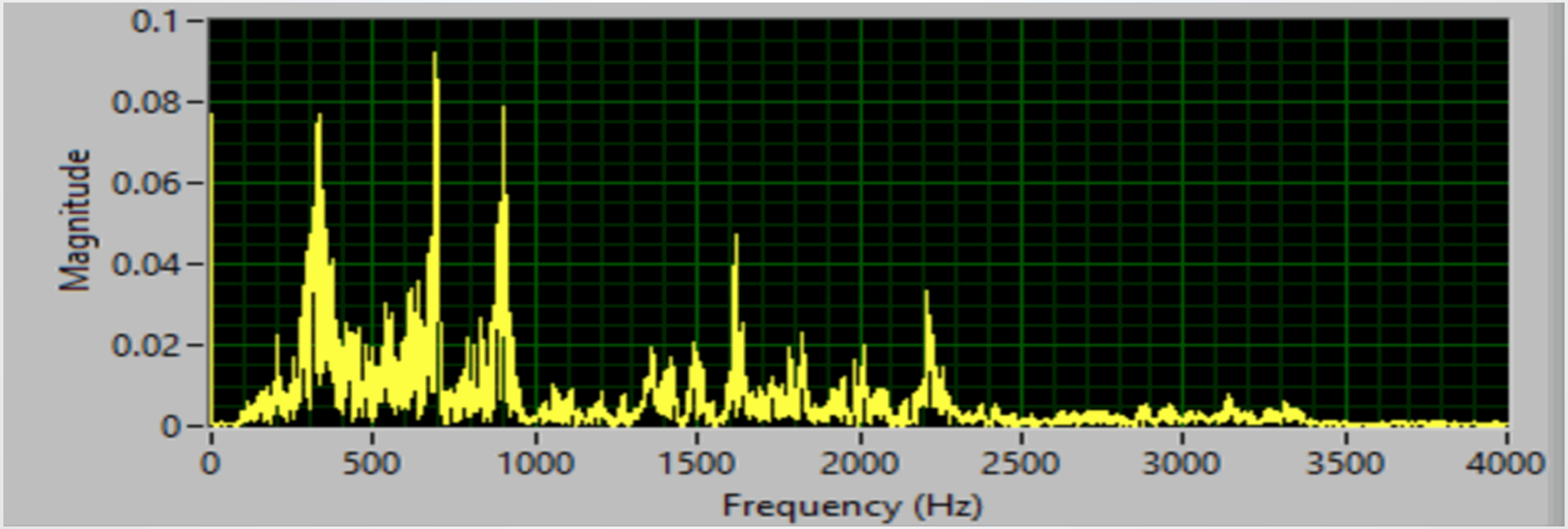
P: liquid pressure

ρ: liquid density

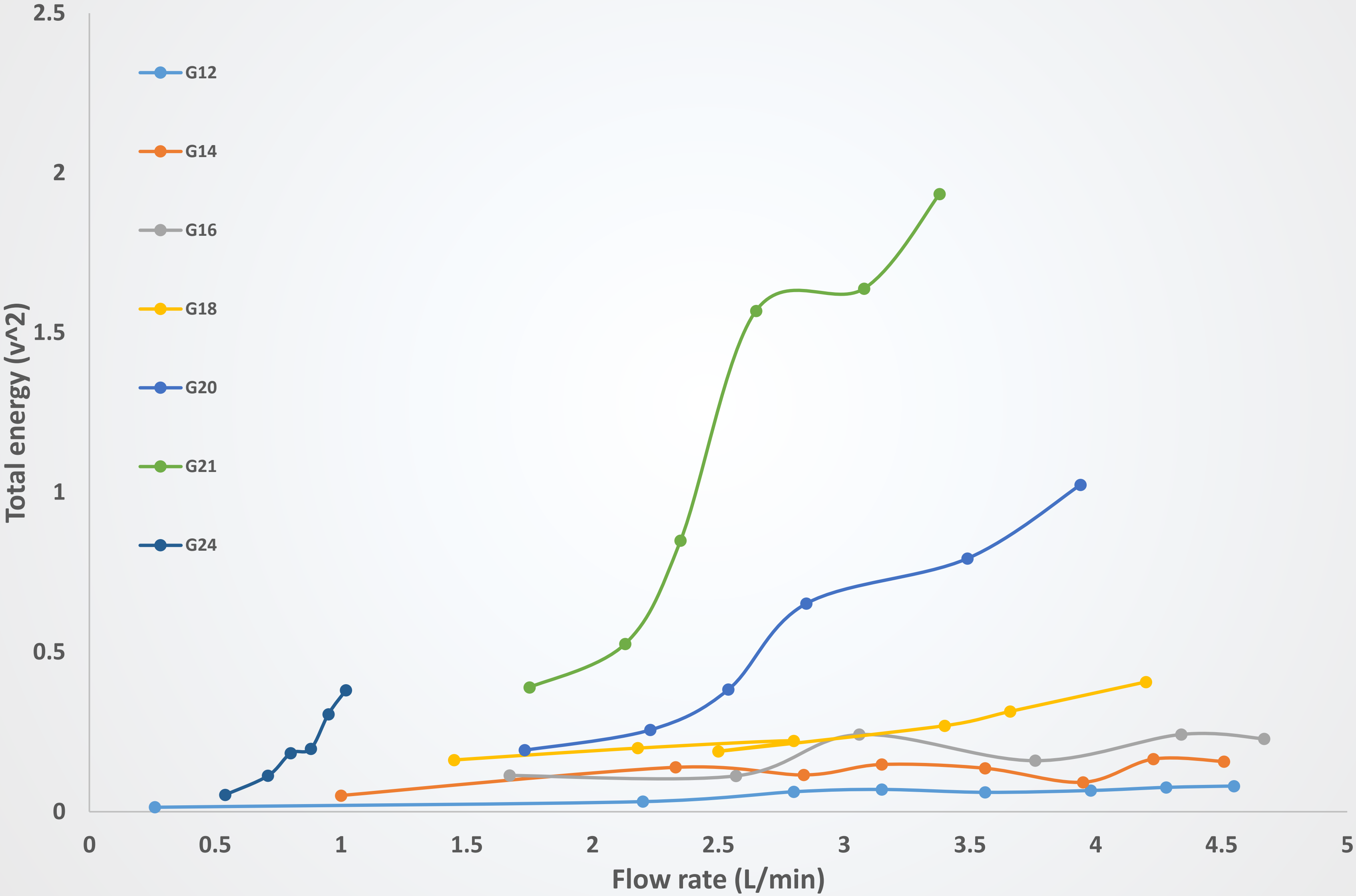
A cluster of bubbles released from a nozzle (high flowrate)

Sound signal and spectrum for a cluster of bubbles

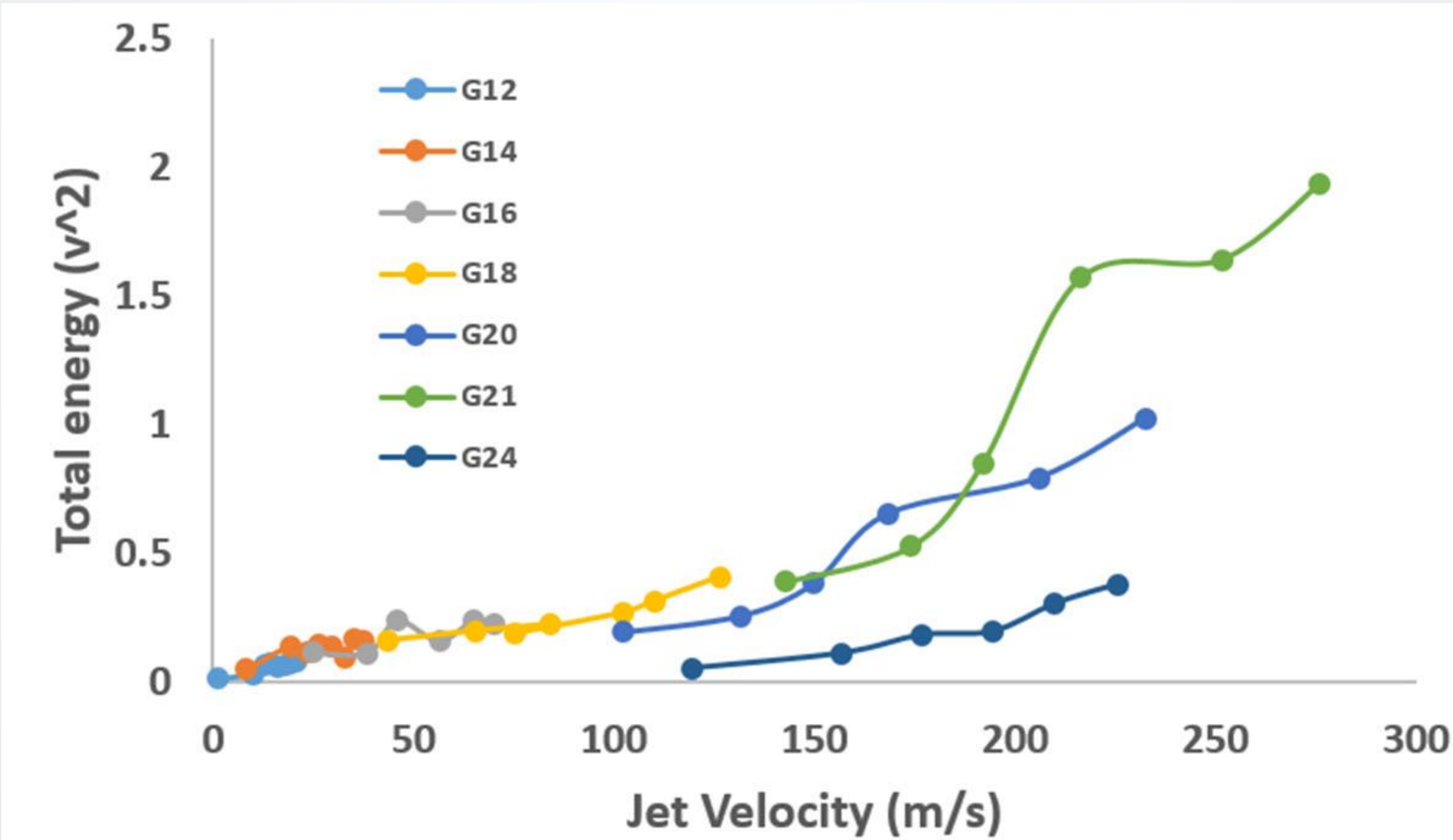




Total Energy vs Flowrate



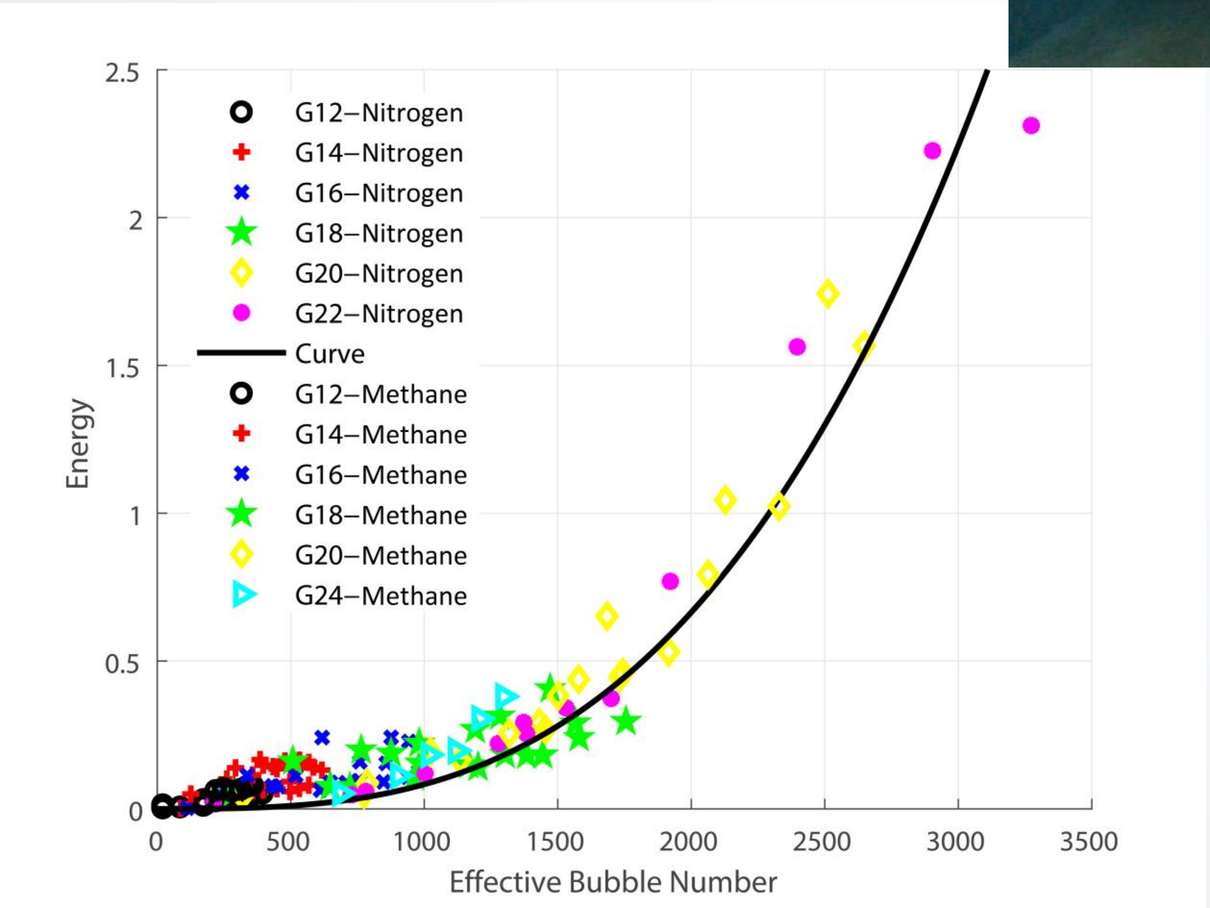
Total energy vs. Jet velocity



A cluster of bubbles (Constant flowrate)

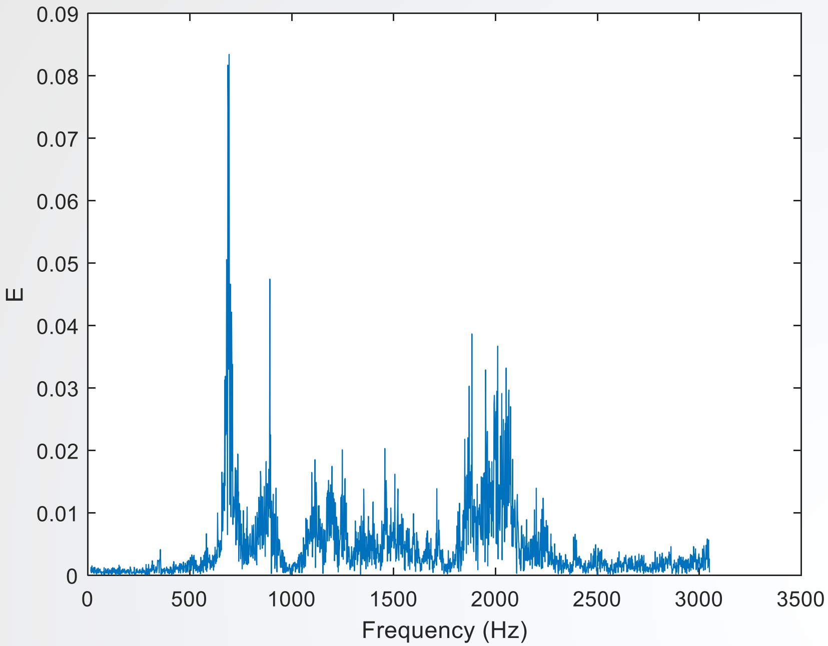
$$n = \frac{FlowRate \times time}{Single\ bubble\ volume}$$

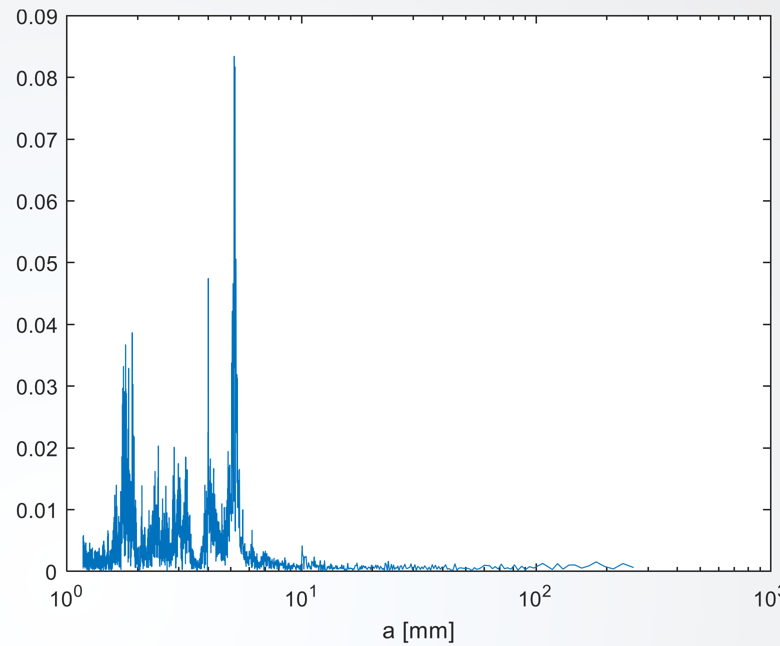
$$E = \frac{A}{D^2} n^3$$

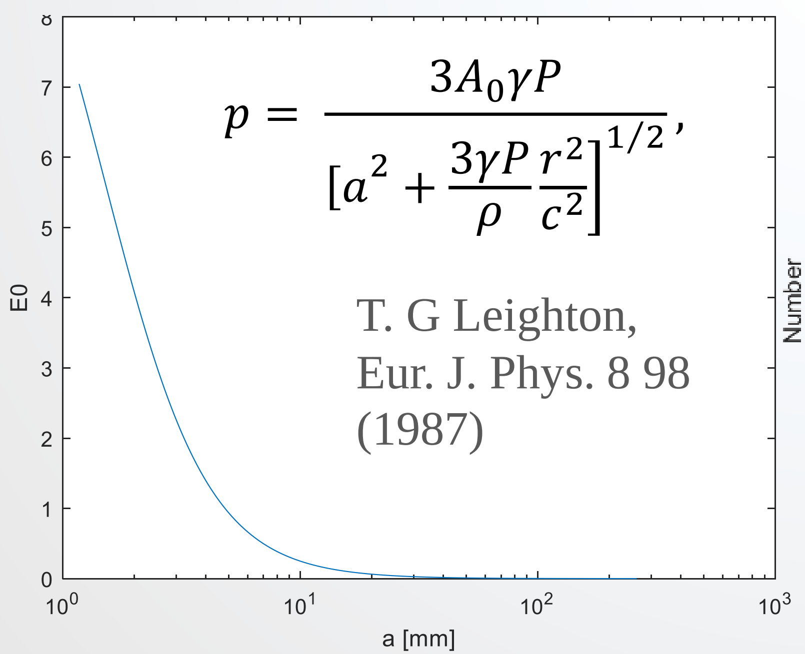


Single bubble volume can be found in *J. Fluid Mech. (1991), vol. 230, pp. 365-390*

Bubble distribution

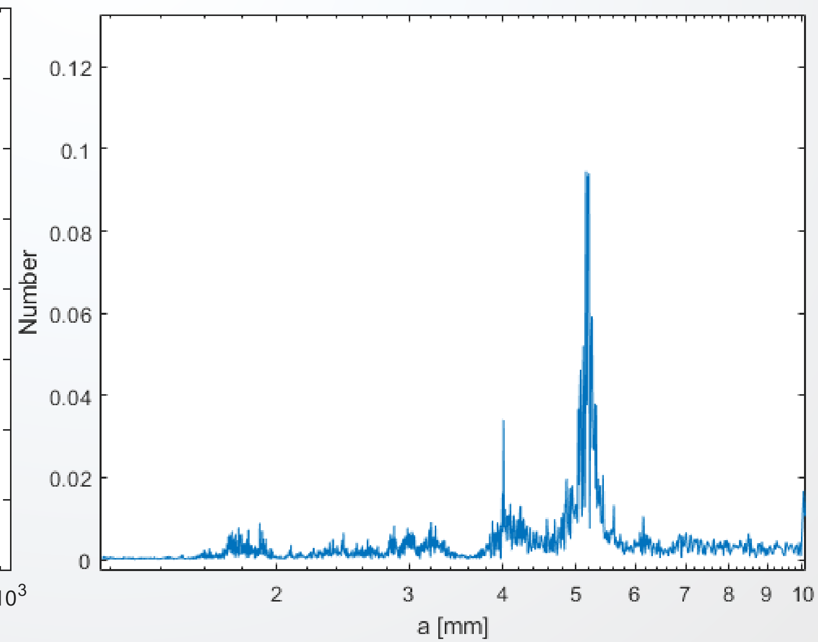




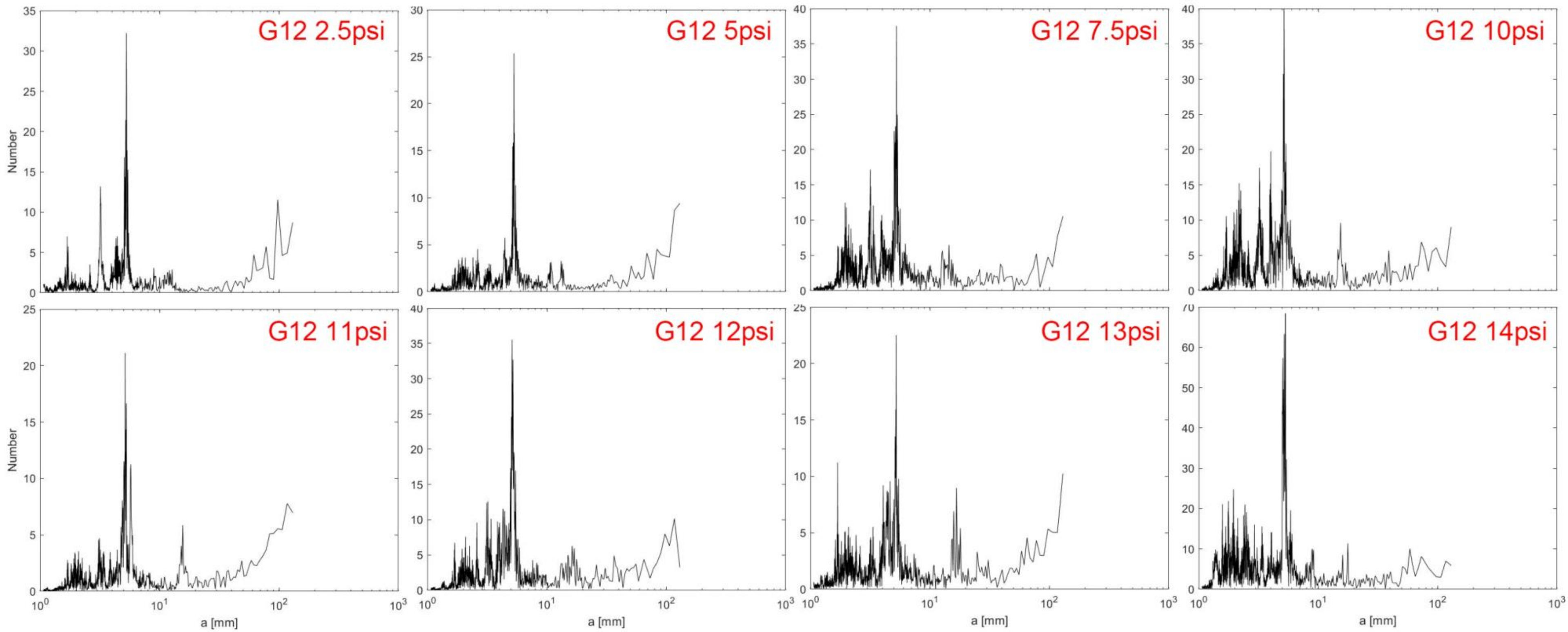


$$p = \frac{3A_0\gamma P}{\left[a^2 + \frac{3\gamma P}{\rho}\frac{r^2}{c^2}\right]^{1/2}},$$

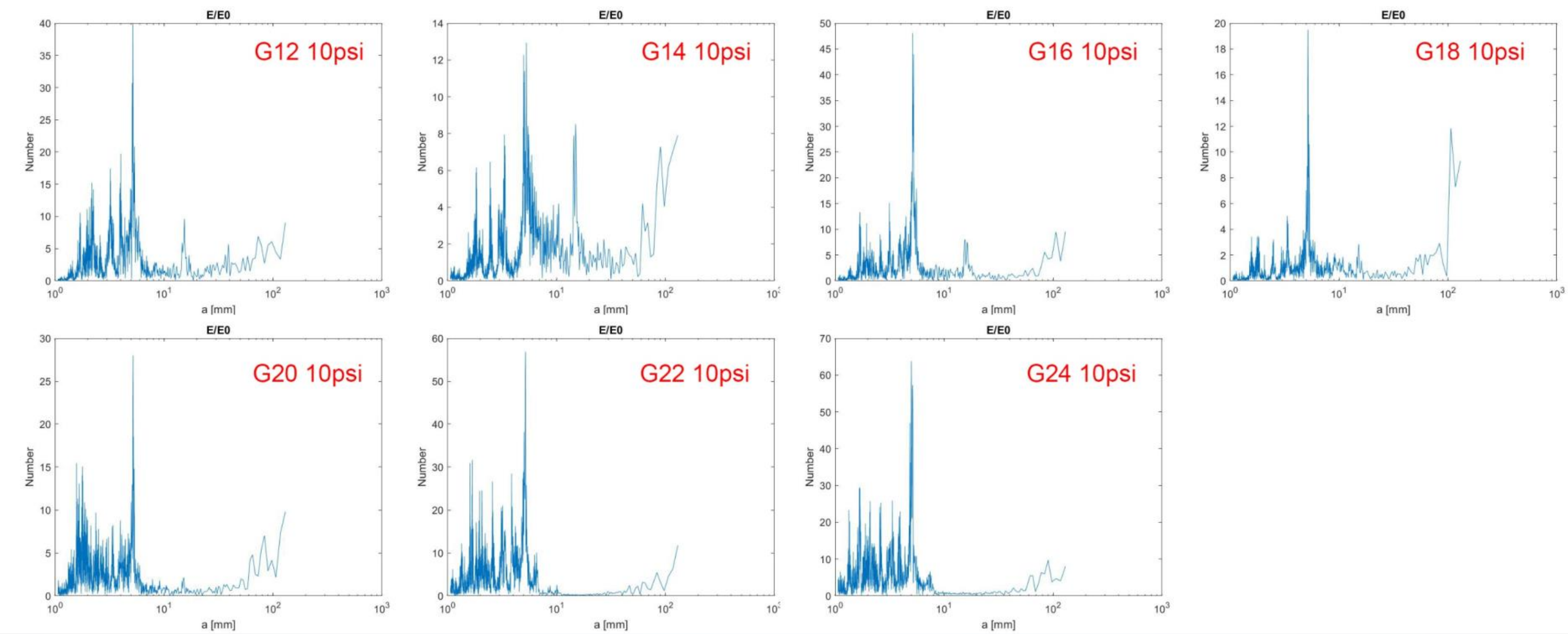
T. G Leighton, Eur. J. Phys. 8 98 (1987)



Keep Diameter Change Flowrate



Change Diameter Keep Flowrate



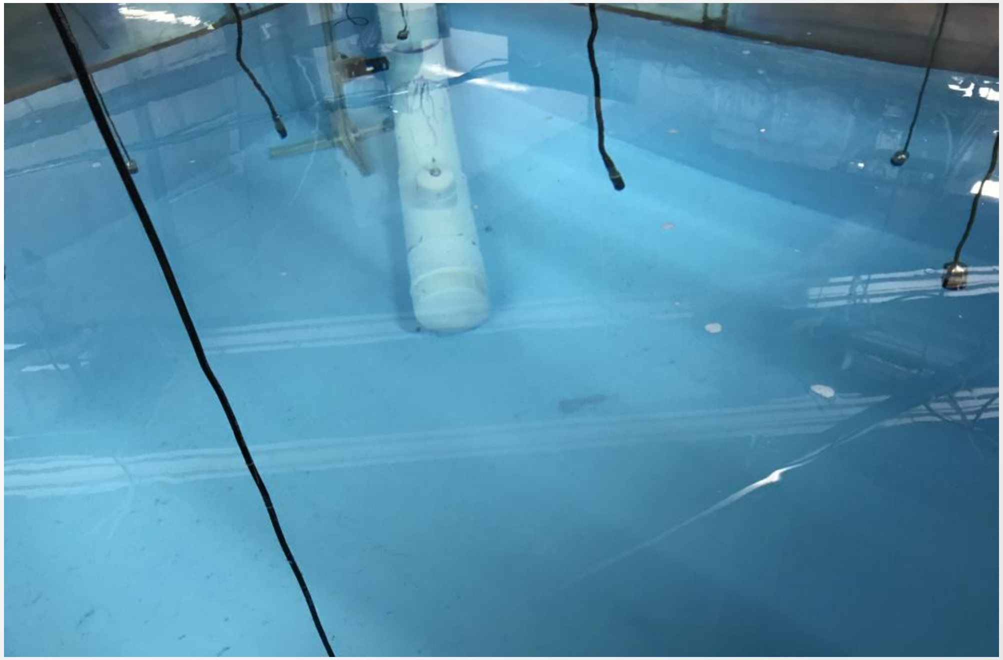
Summary

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

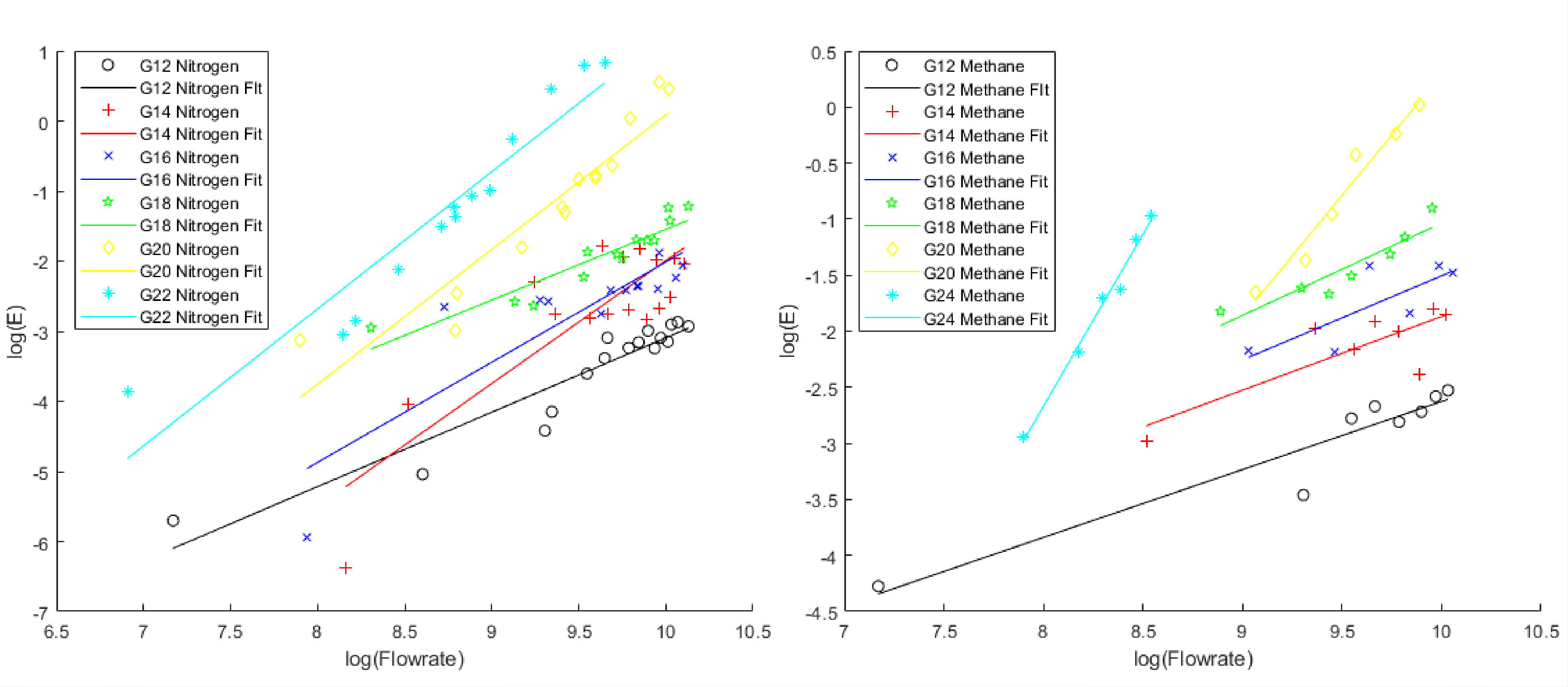
Funding from Gulf Research Program of the National Academy of Sciences with award number: 2000008860.

log(Total Energy) vs log(Flowrate)

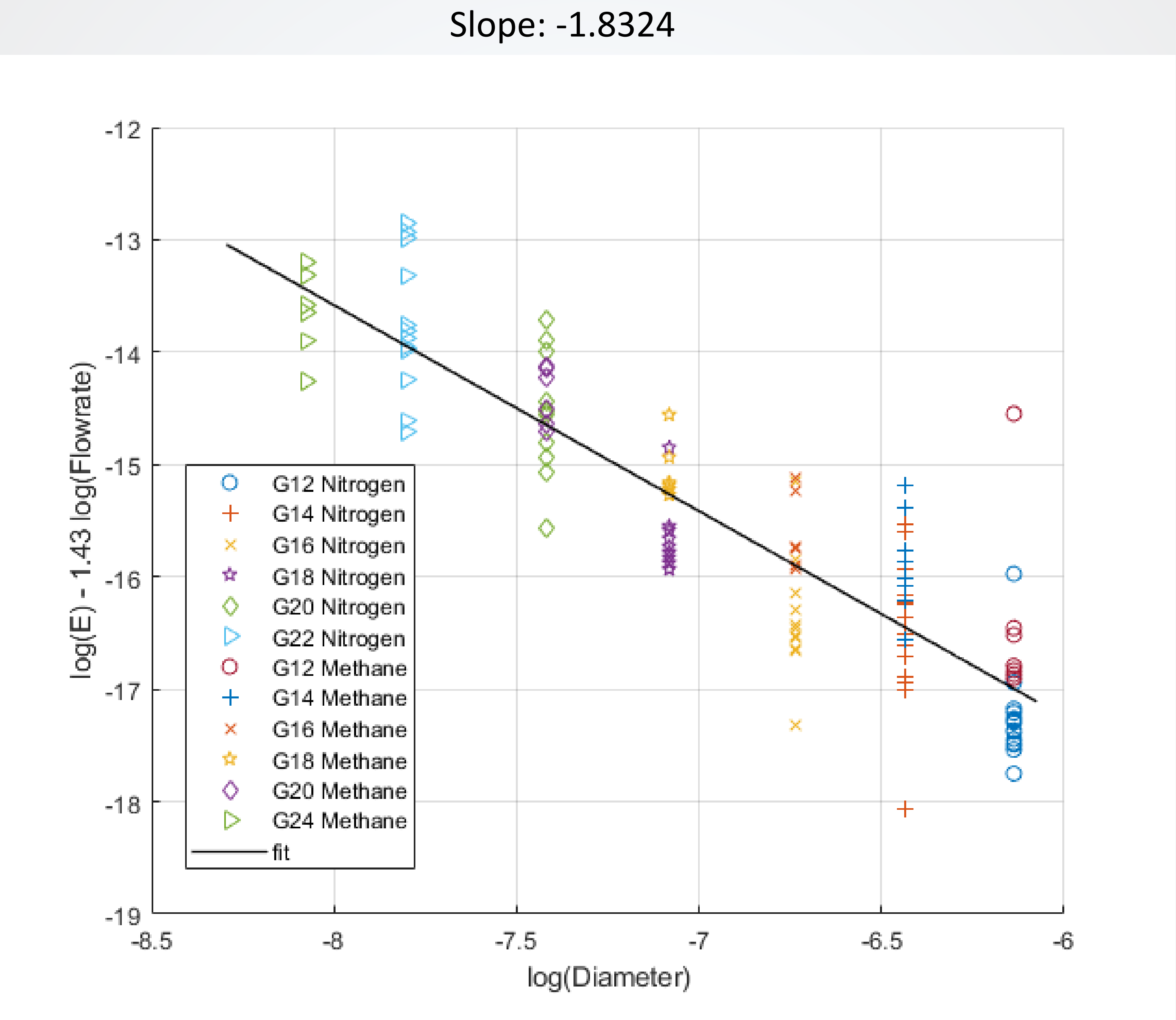
Slope:

Mean value: 1.433

Standard deviation: 0.755



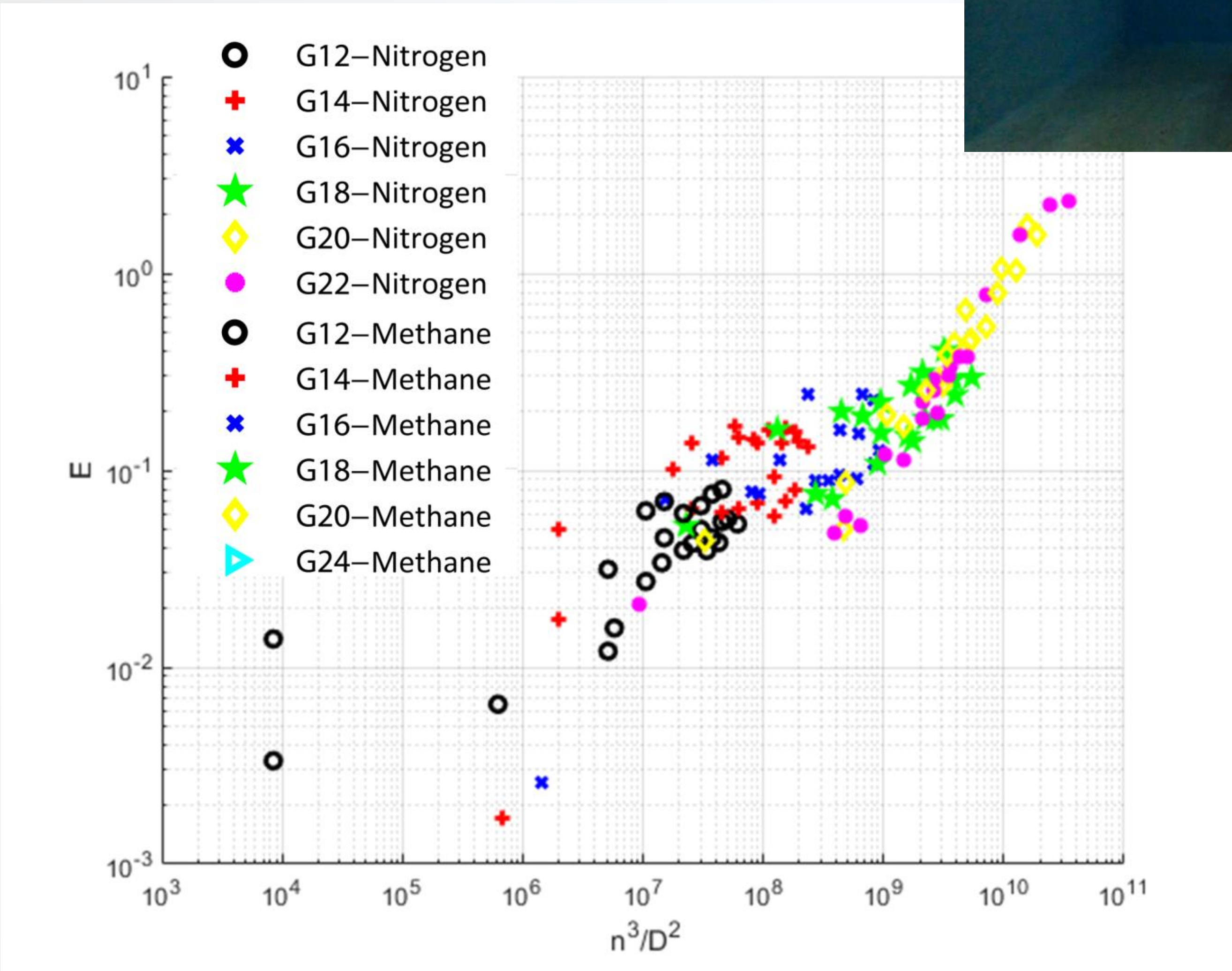
log(E) vs log(Diameter)



A cluster of bubbles (Constant flowrate)

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

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



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

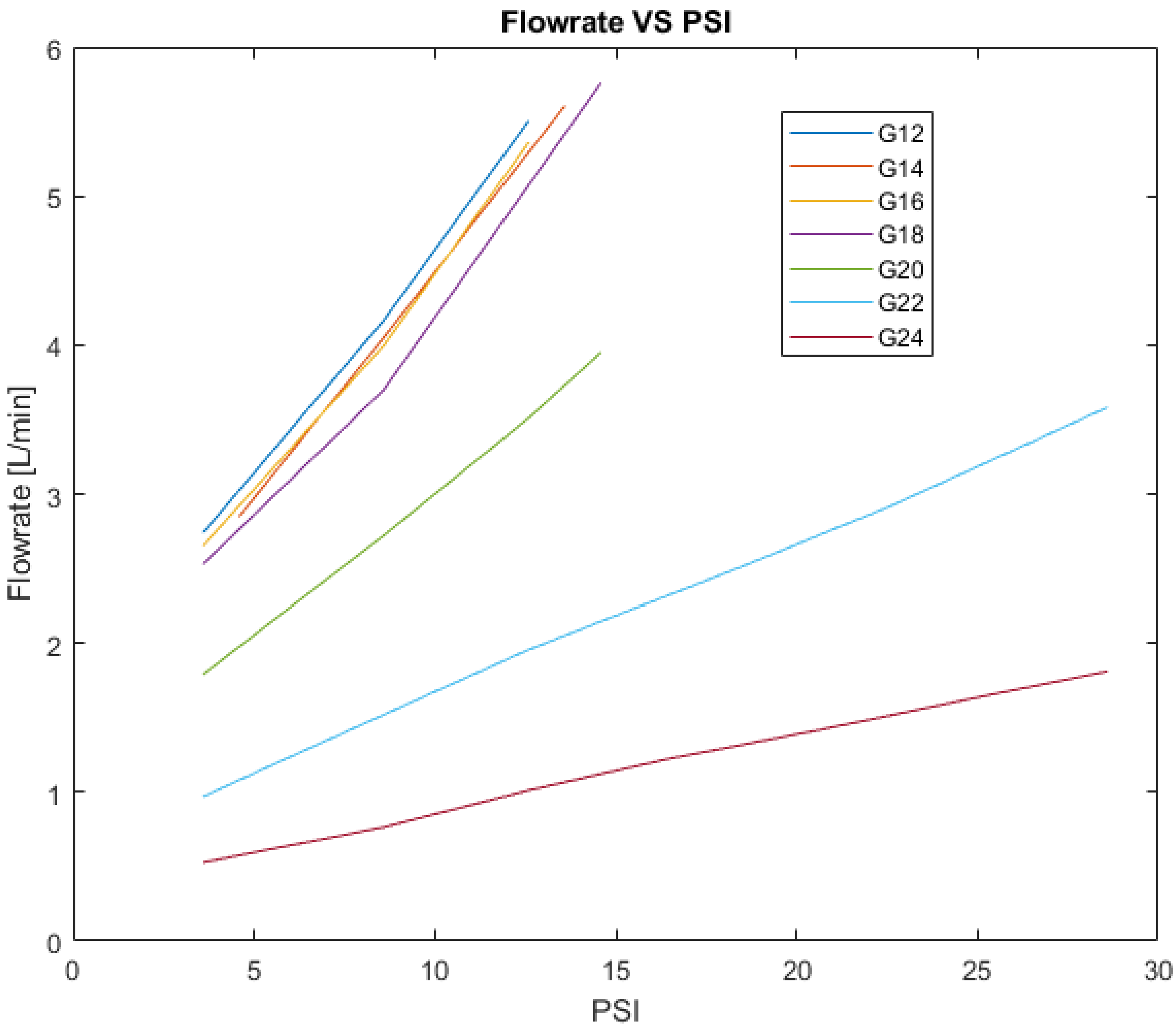
Oil spills spread rapidly. Once the oil expands to a wide area extraction is **difficult** and **expensive.**

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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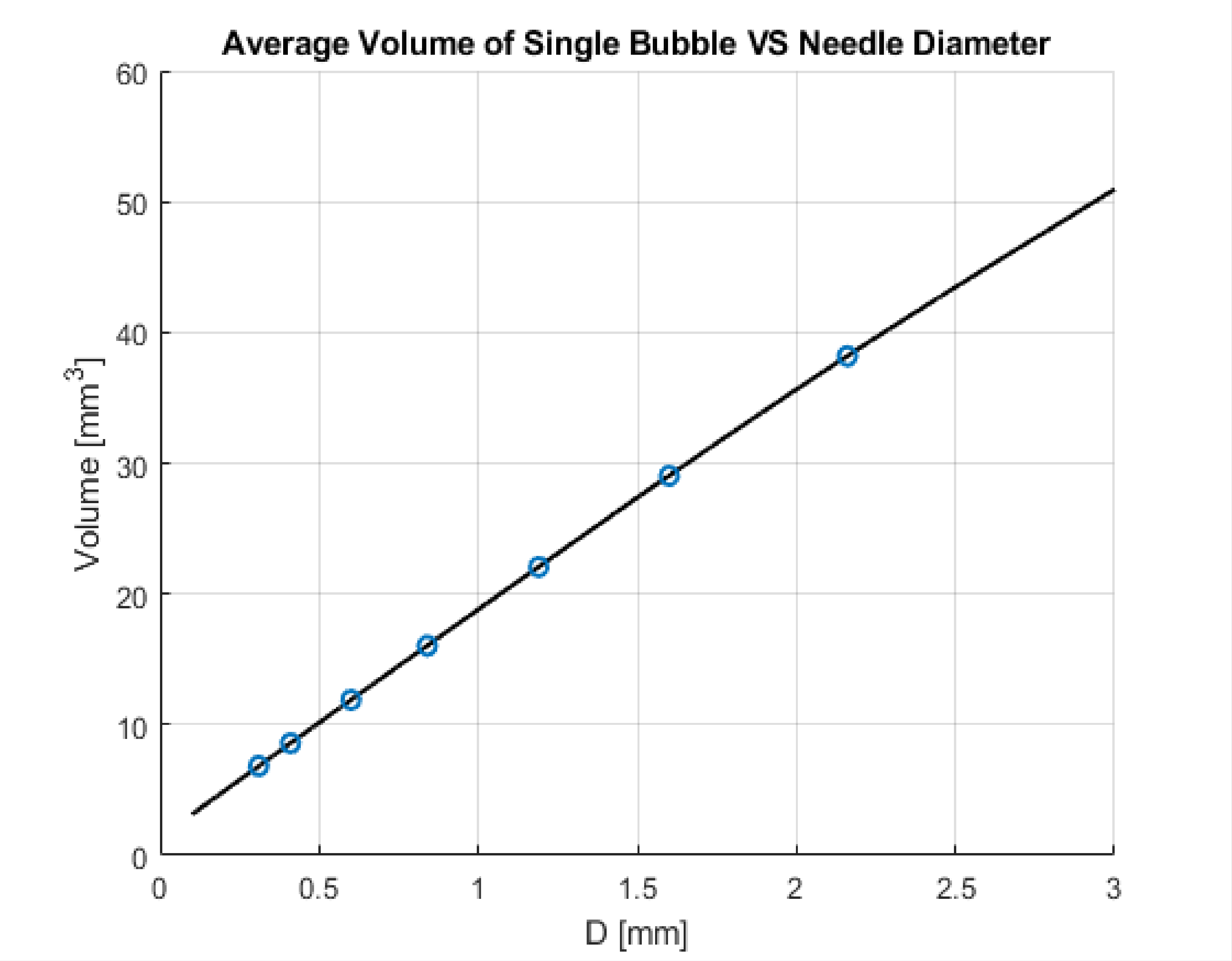
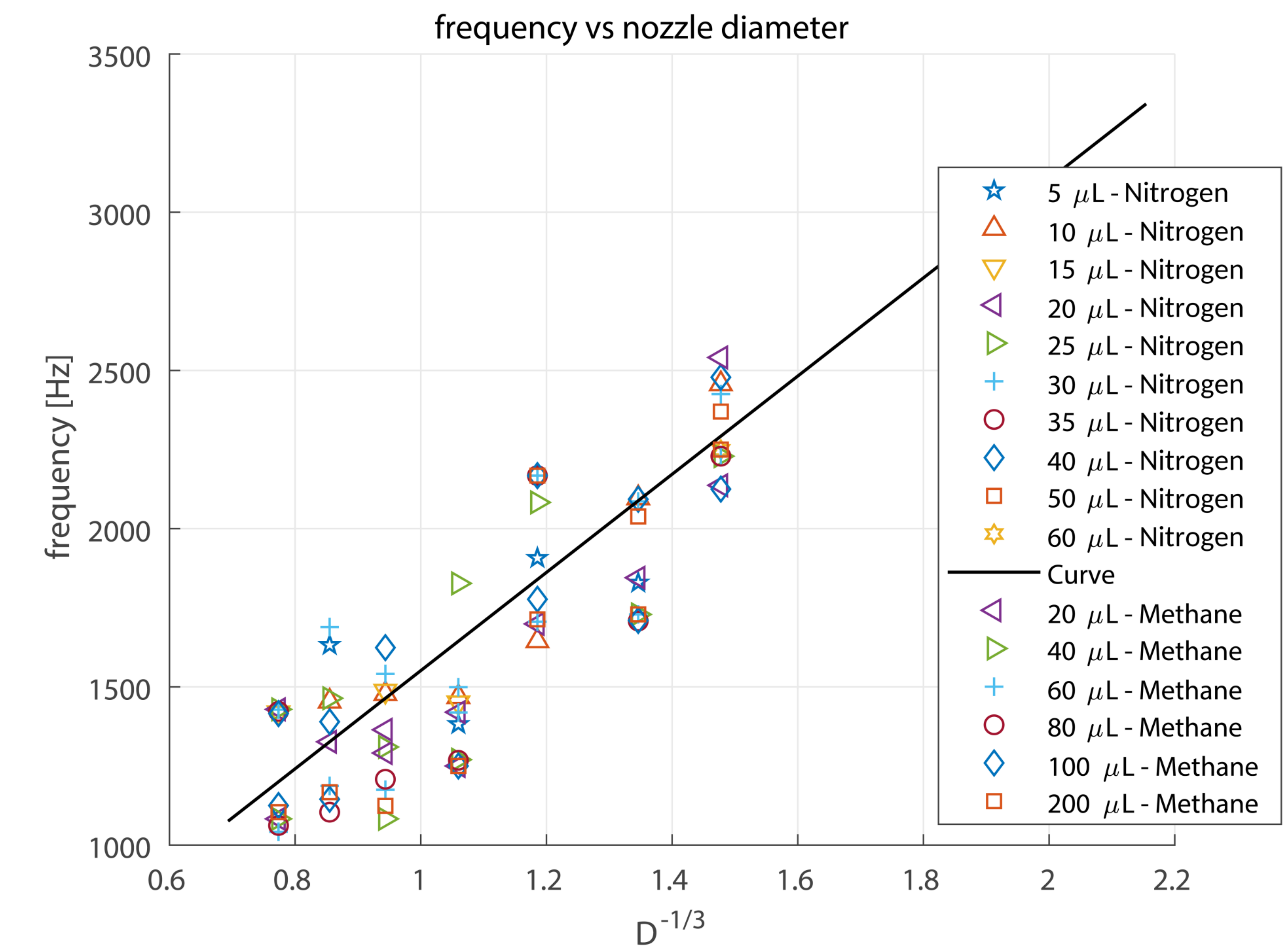
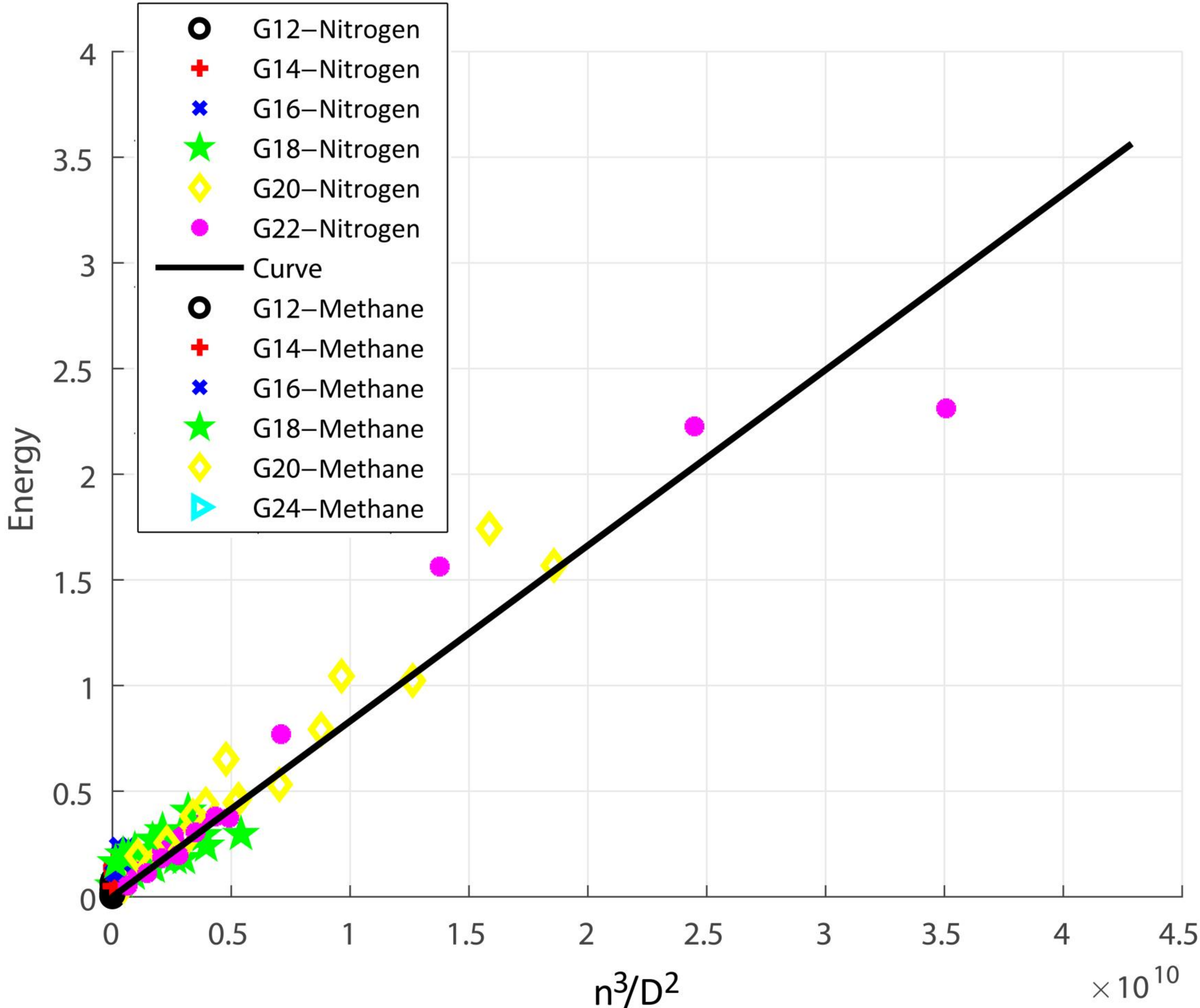


Data from *J. Fluid Mech. (1991), vol. 230, pp. 365-390*



frequency vs nozzle diameter
frequency [Hz]
3500
3000
2500
2000
1500
1000
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
D$^{-1/3}$
5 μL - Nitrogen
10 μL - Nitrogen
15 μL - Nitrogen
20 μL - Nitrogen
25 μL - Nitrogen
30 μL - Nitrogen
35 μL - Nitrogen
40 μL - Nitrogen
50 μL - Nitrogen
60 μL - Nitrogen
Curve
20 μL - Methane
40 μL - Methane
60 μL - Methane
80 μL - Methane
100 μL - Methane
200 μL - Methane



G12−Nitrogen
G14−Nitrogen
G16−Nitrogen
G18−Nitrogen
G20−Nitrogen
G22−Nitrogen
Curve
G12−Methane
G14−Methane
G16−Methane
G18−Methane
G20−Methane
G24−Methane
Energy
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
$\times 10^{10}$
n^3/D^2

Summary

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