9.

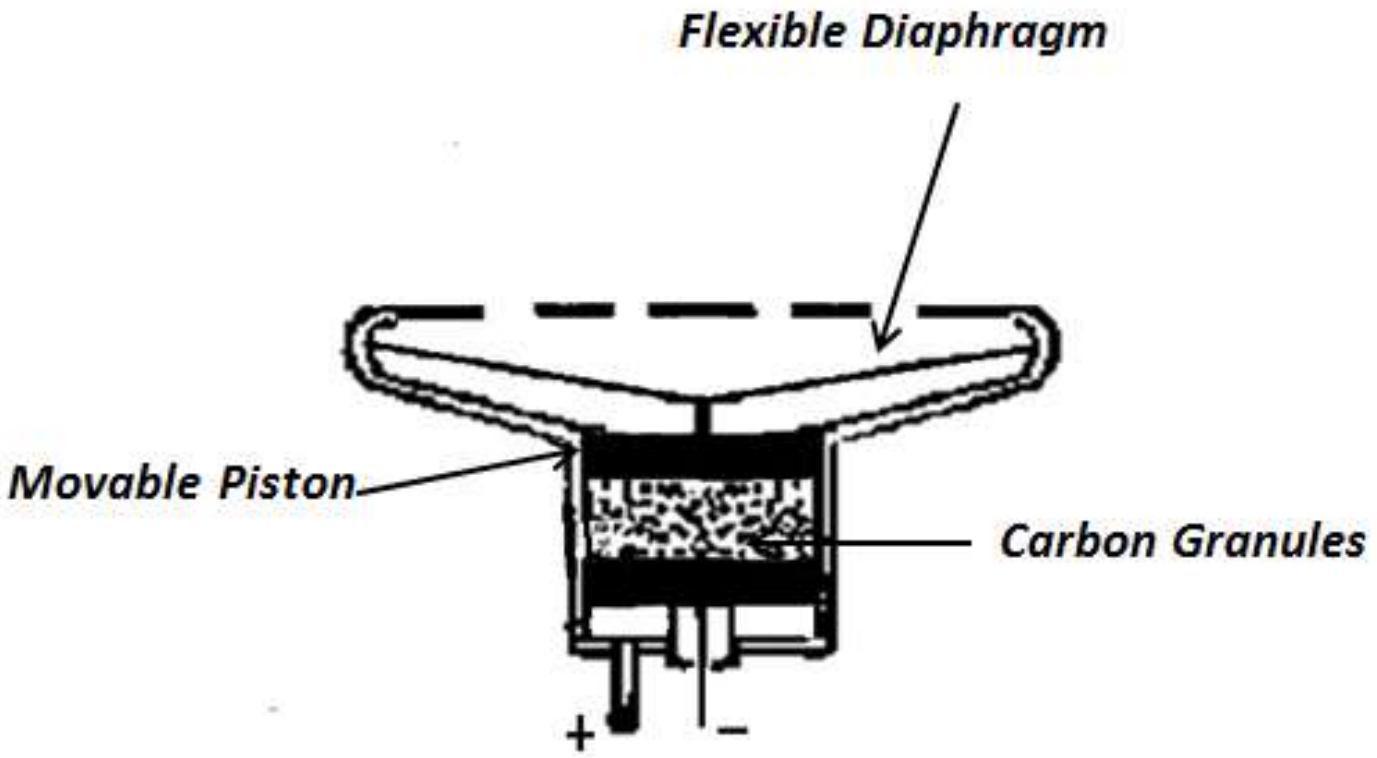
Carbon Microphone

Marco Bodnár

Task

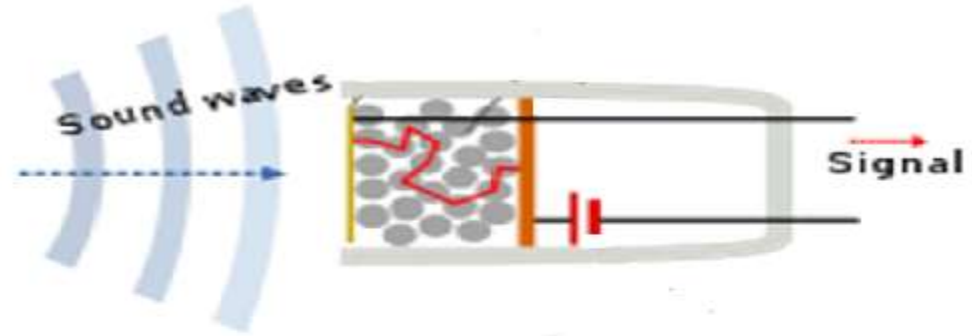
For many years, a design of microphone has involved the use of carbon granules. Varying pressure on the granules produced by incident sound waves produces an electrical output signal. Investigate the components of such a device and determine its characteristics.

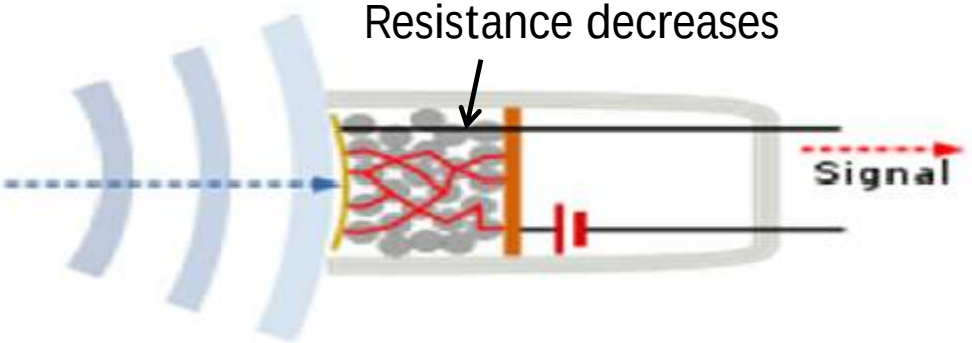
Basic scheme

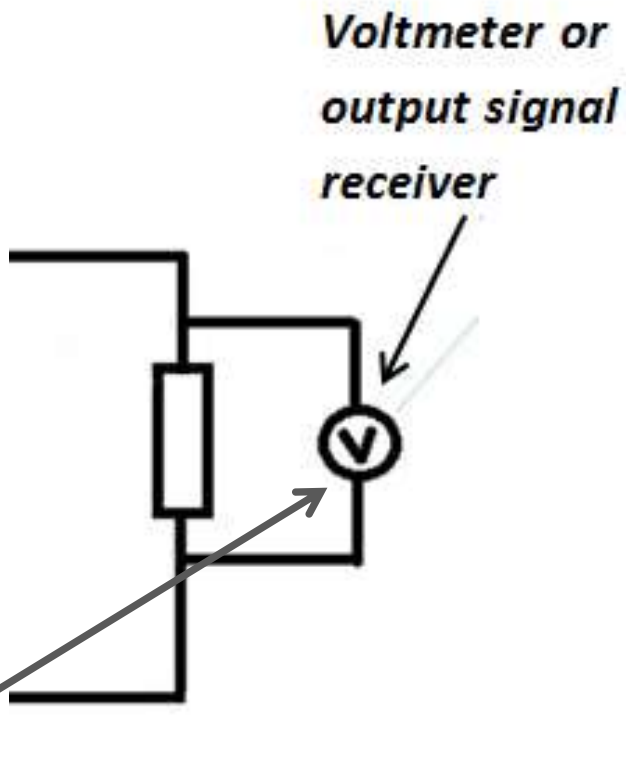


Carbon Microphone

Basic scheme and principle







Current is dynamic → Voltage drop across resistor is dynamic

Factory assembled microphone

Chamber

Carbon powder

Cover

Elastic membrane

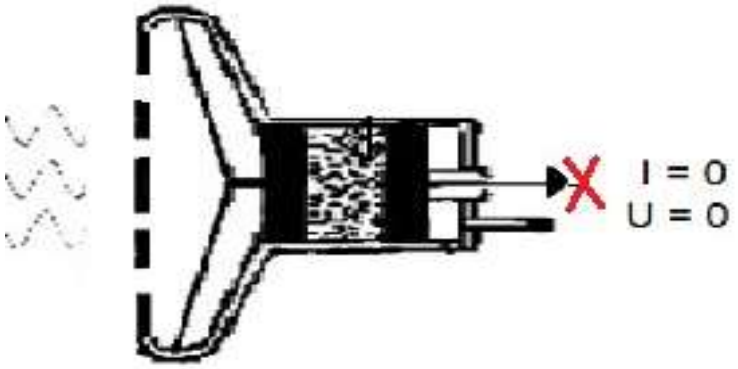
Covering membrane

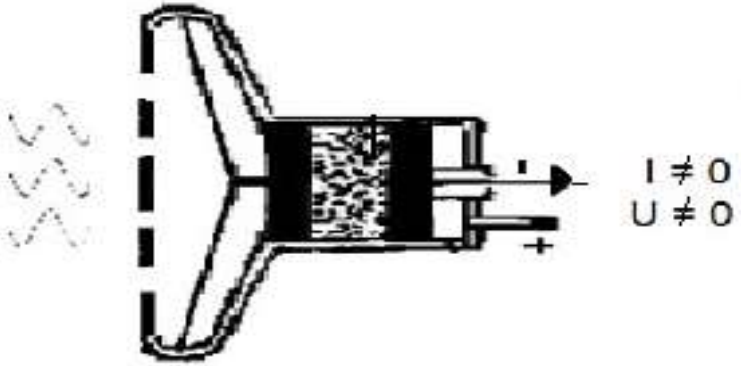
Microphone base

Voltage is needed

MICROPHONE IS PASSIVE

- WITHOUT VOLTAGE APPLIED – NO VOLTAGE CHANGE CAN BE MEASURED





Dynamic resistance → Dynamic voltage, current

Measureable

Membrane

- **Radius**
  – change in frequency characteristics
- **Weight**
  – as light as possible
- **Elasticity**

Why carbon powder?

- **Bad conductor**
  (in comparison with metals)
  - sensitivity of microphone
  - ideally no added substances
- **Stable**
  - does not change structure with temperature or other conditions*

Very high sensitivity (of its resistivity) to pressure change

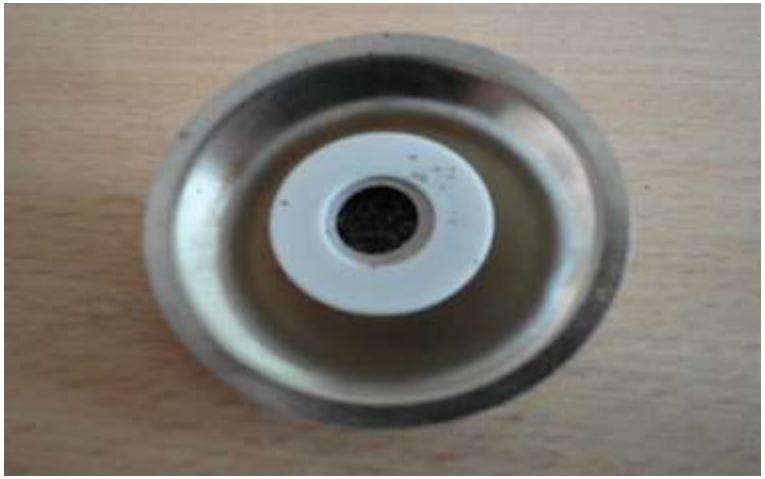
*to a certain extent

Covers

Front foil – protects from dirt

- Protect inner parts of microphone (not necessary for correct functioning)

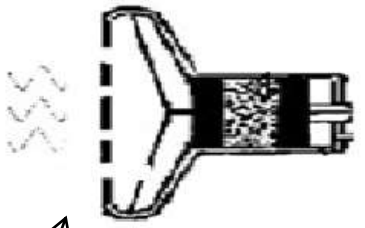
Back cover – protects from mechanical damage

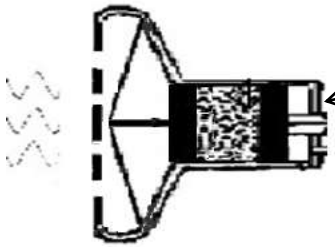


Hole in diaphragm

- Hole in diaphragm used for pressure equalisation

With hole – equal pressure inside the microphone and outside– diaphragm remains same

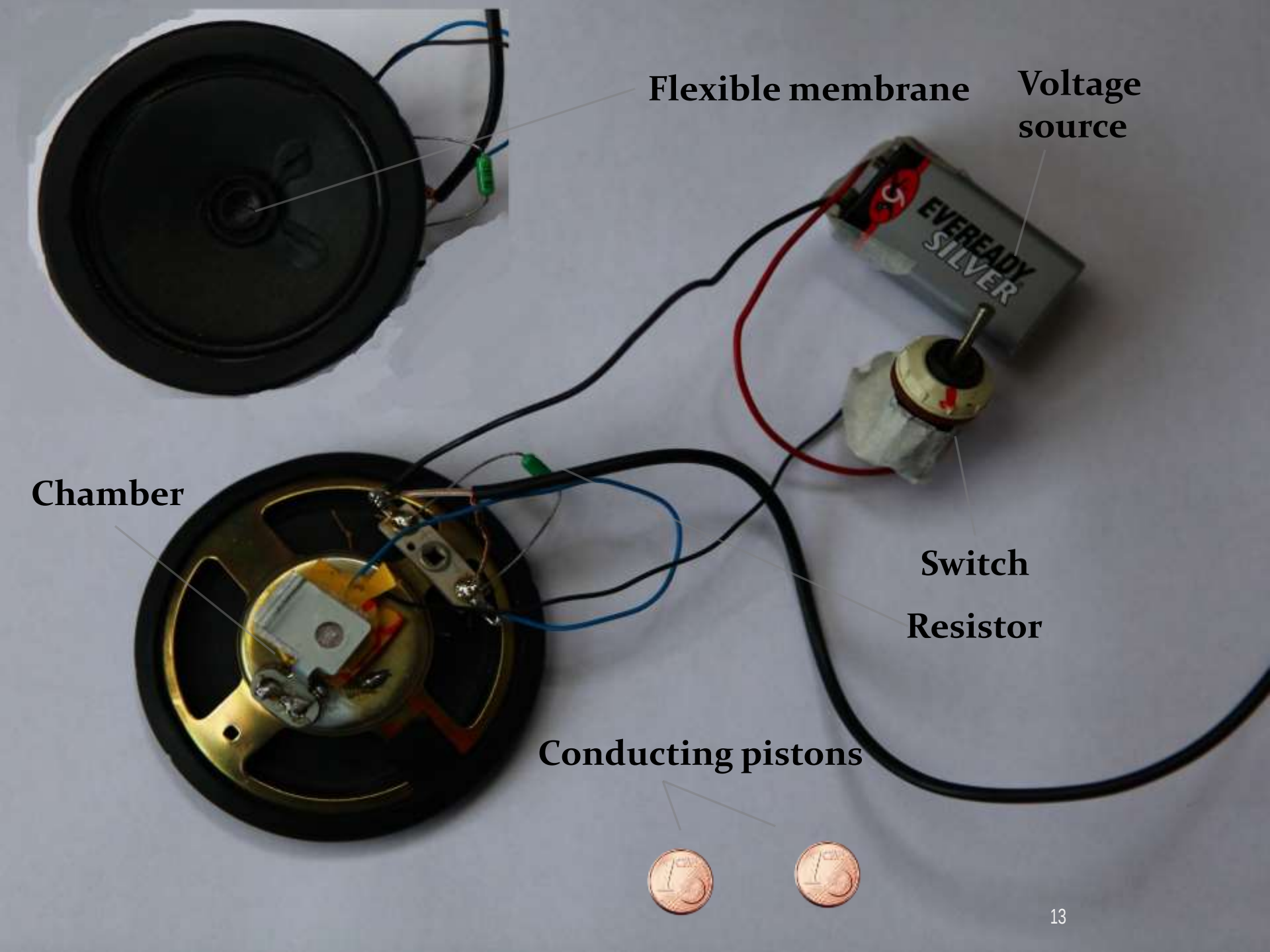


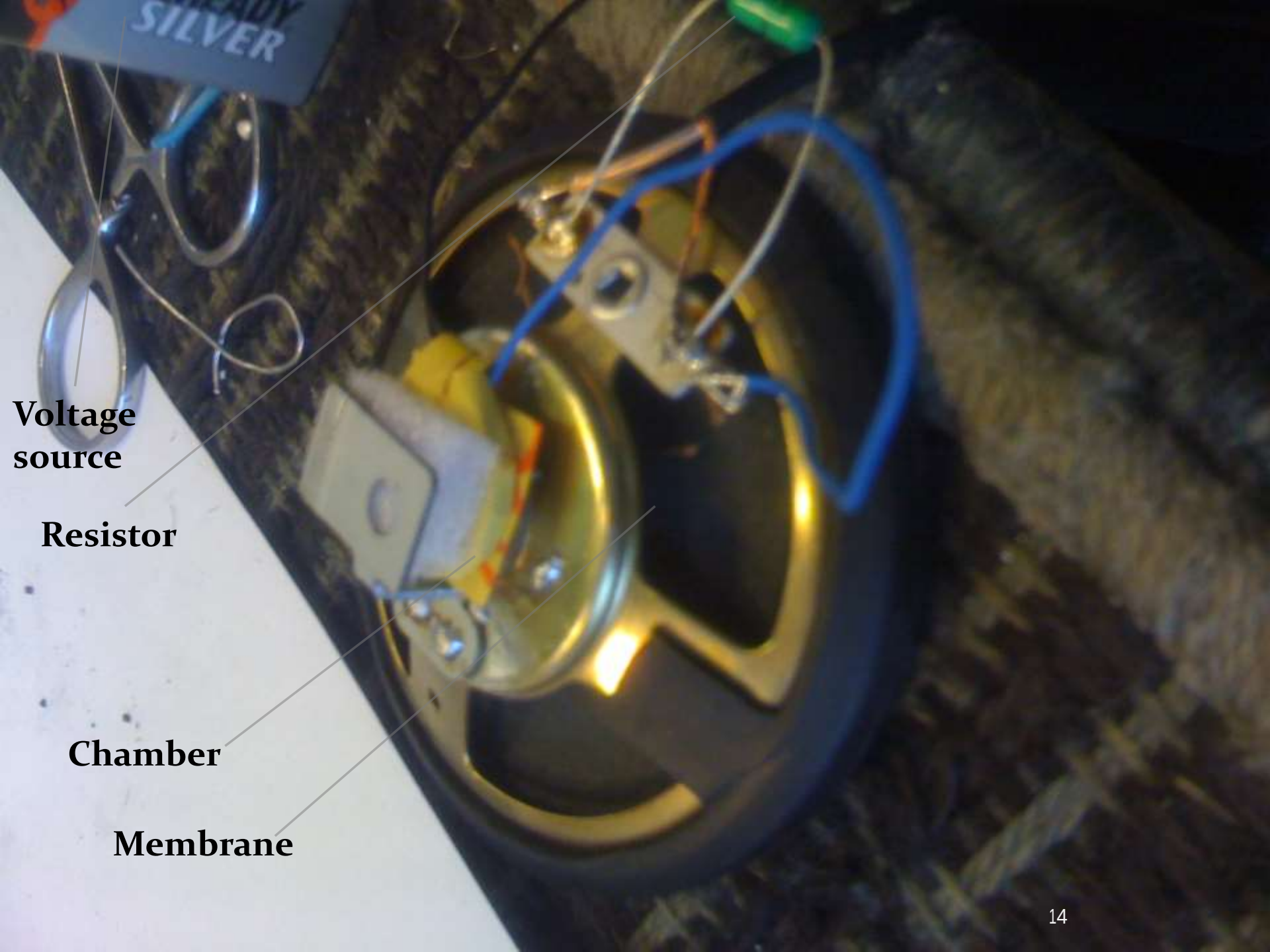


Without hole – overpressure inside the microphone – diaphragm bulks out

Now that we know how it works...

...we will try to make our own.

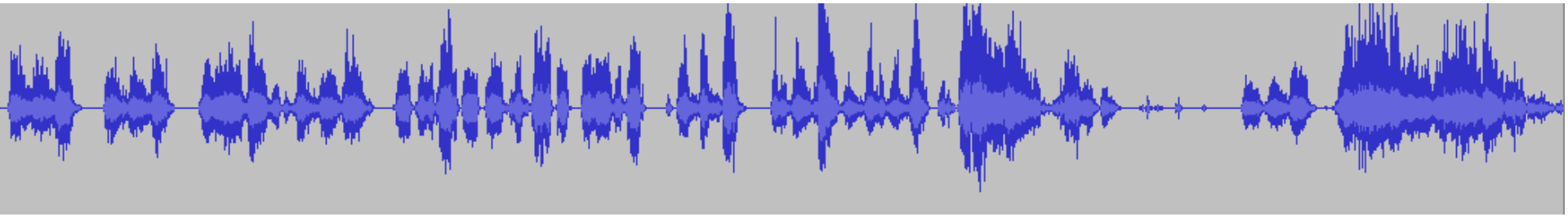

Flexible membrane
Voltage source
EVEREADY
SILVER
Chamber
Switch
Resistor
Conducting pistons


Voltage source
Resistor
Chamber
Membrane

Home made record

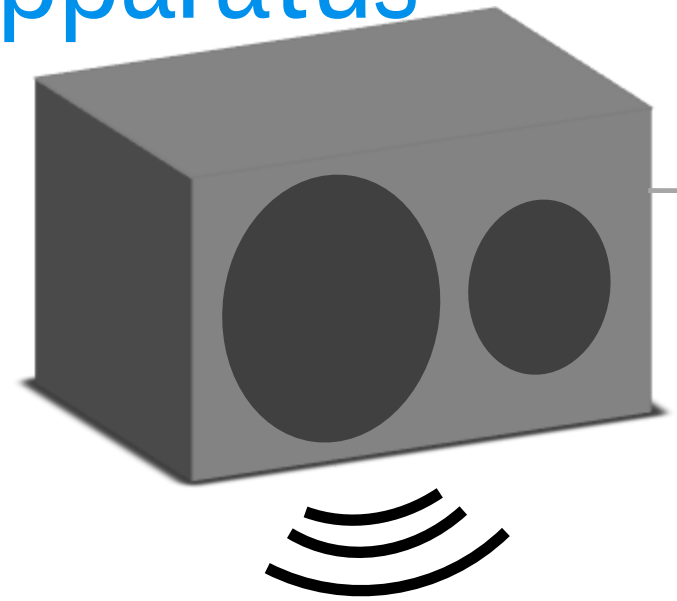
Home made
R=5000Ω

Home made



Further measurements with factory assembled microphone **only**.

Apparatus

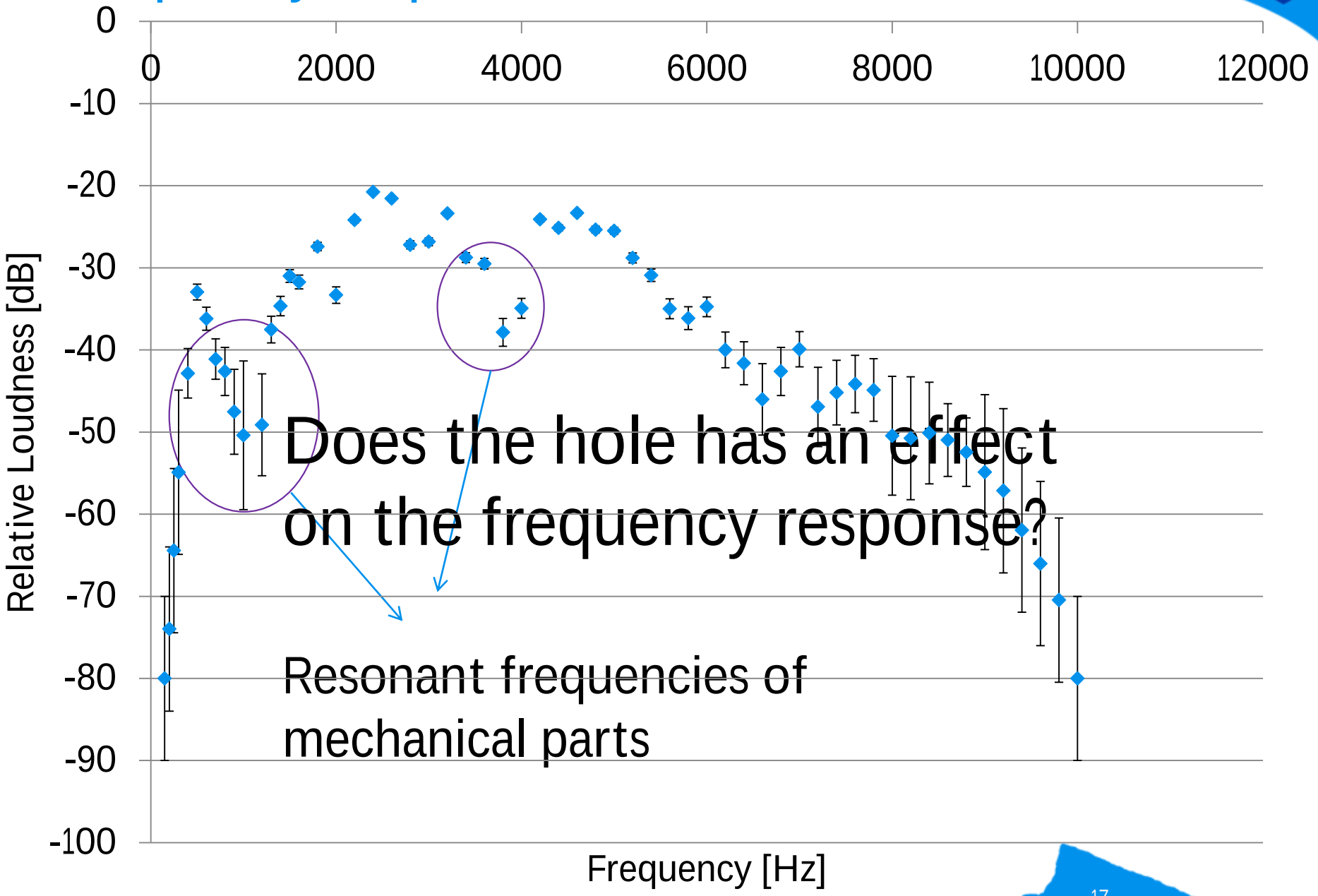


Sound production

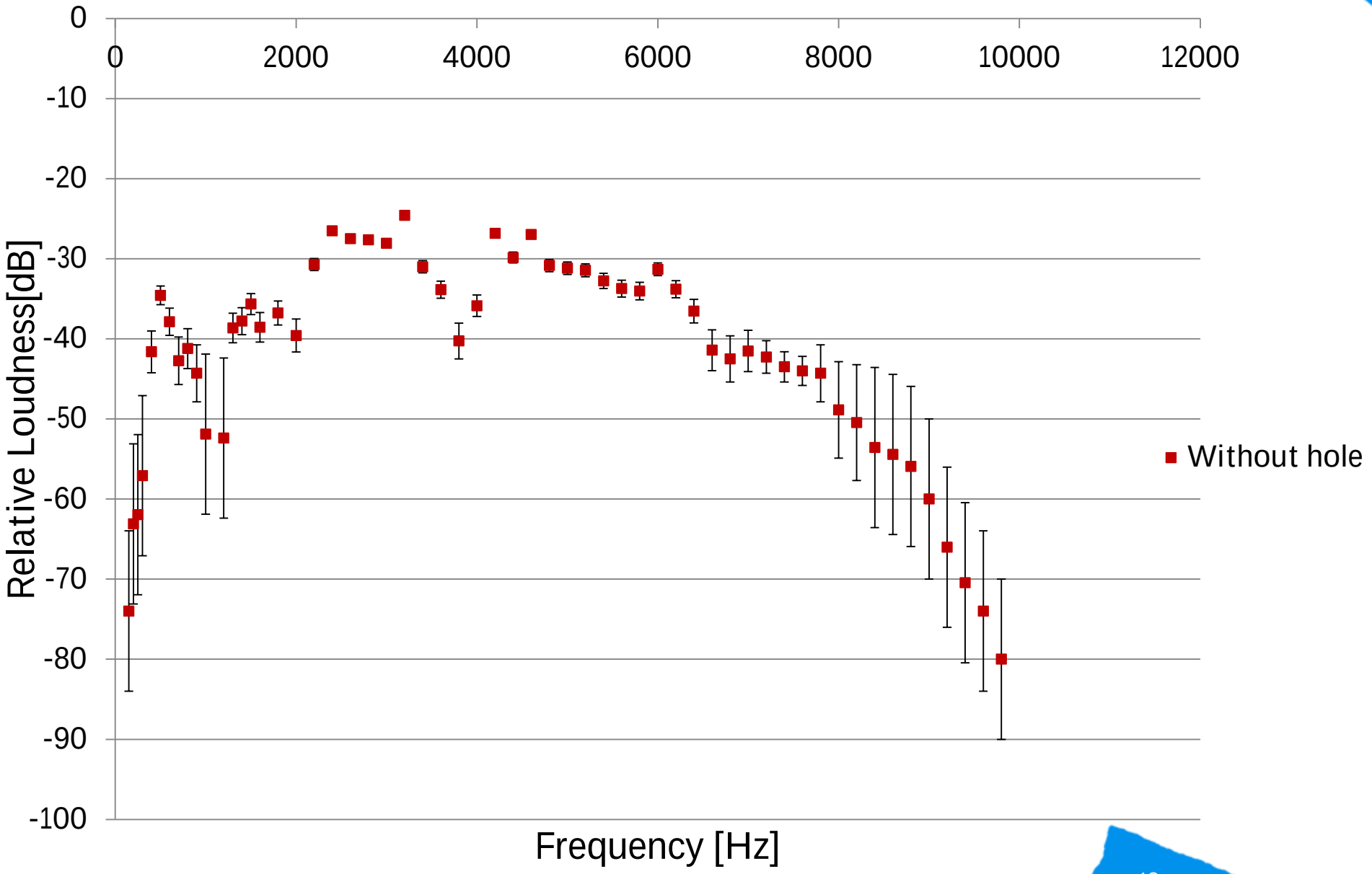
Loudness meter

Sound analysis

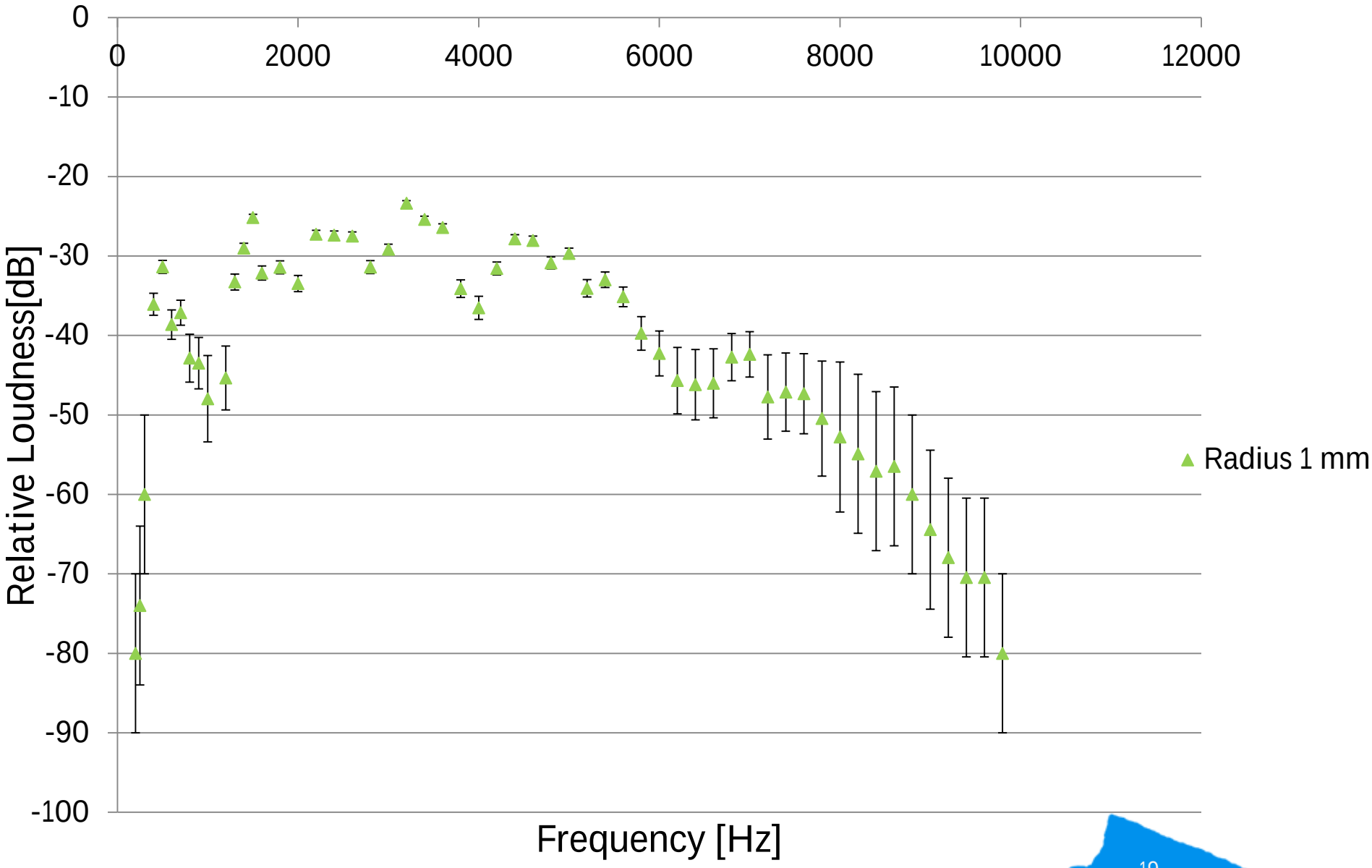
Frequency response at 94 dB



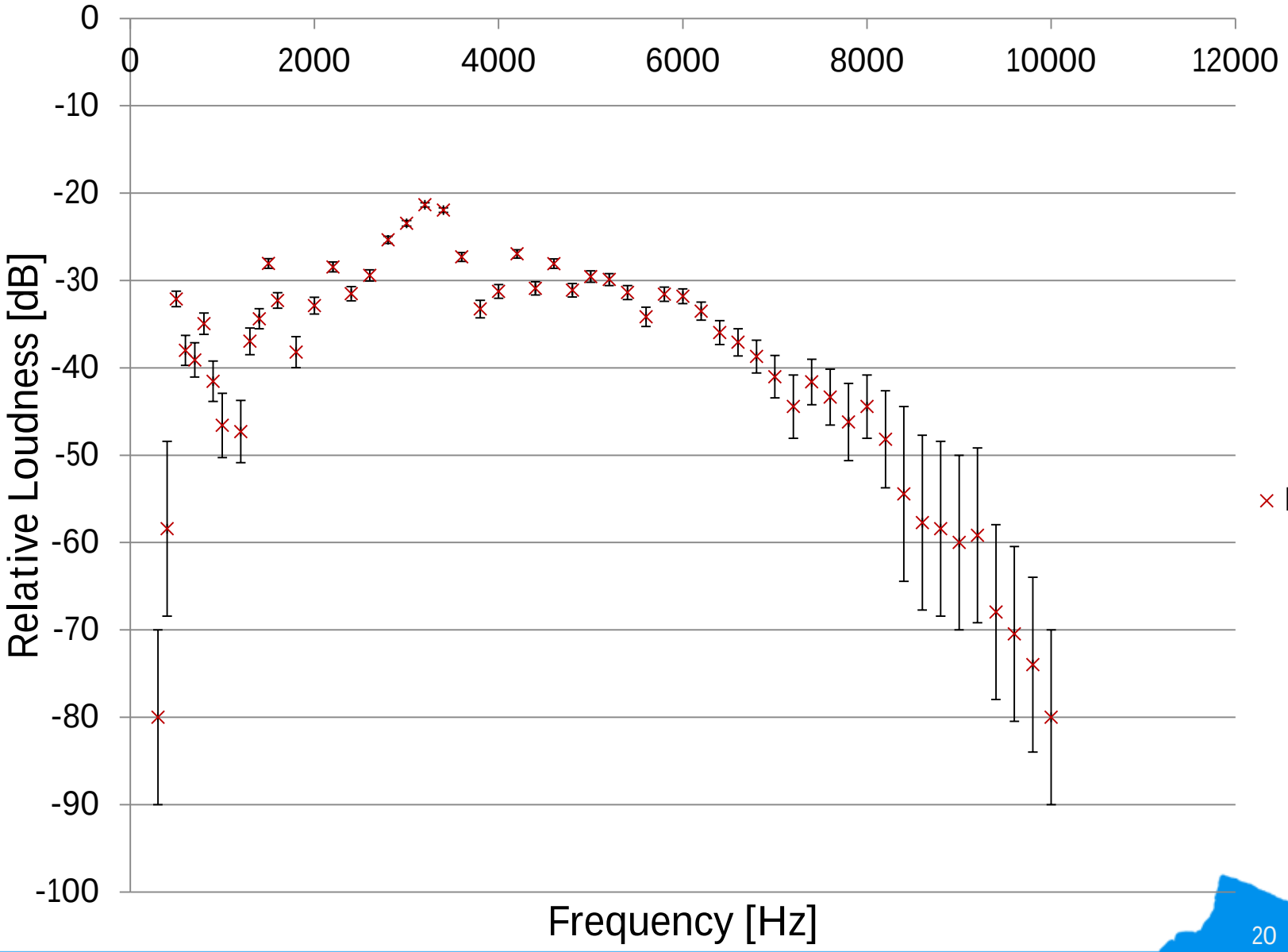
Frequency response at 94 dB - hole effect



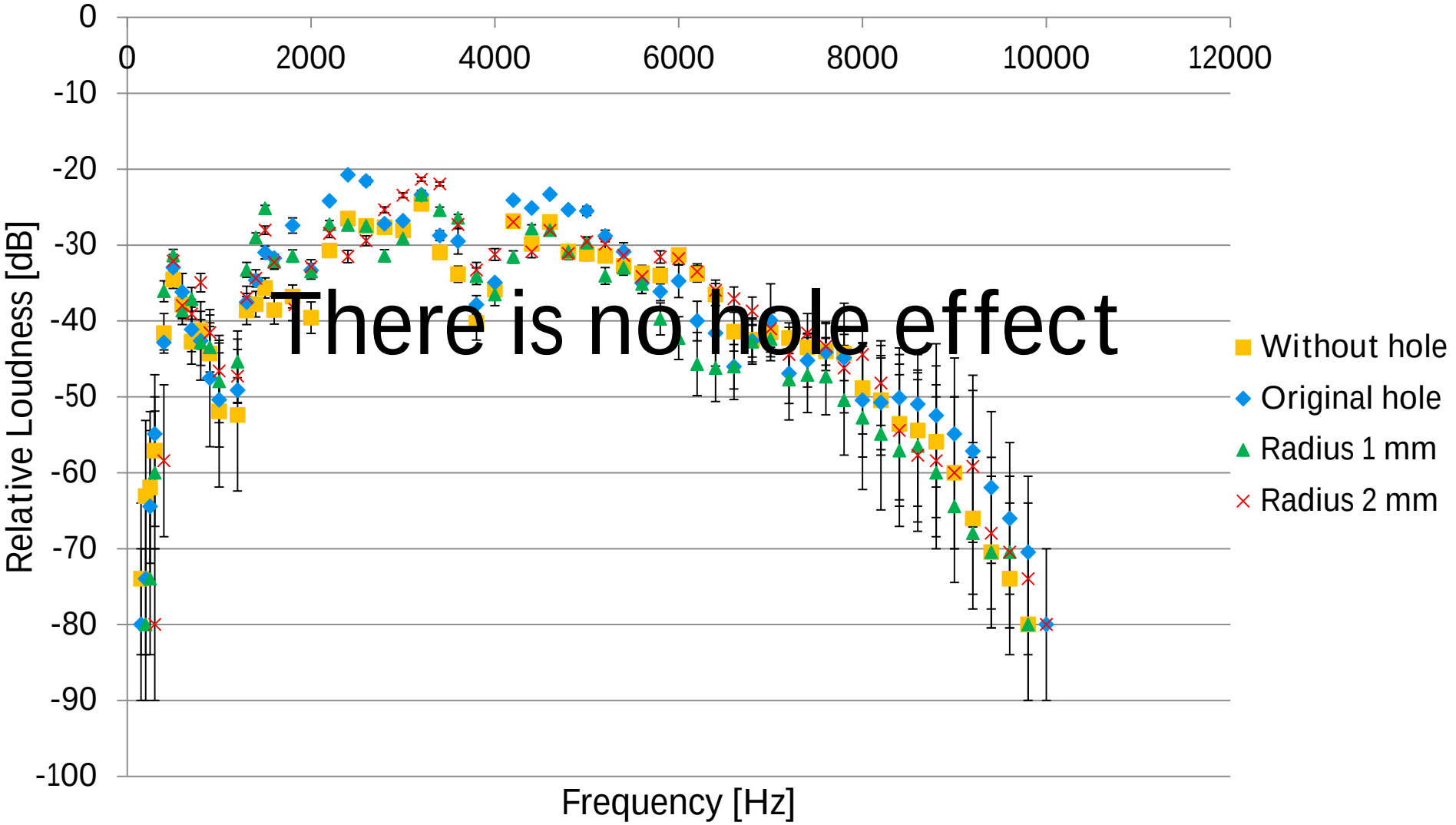
Frequency response at 94 dB - hole effect



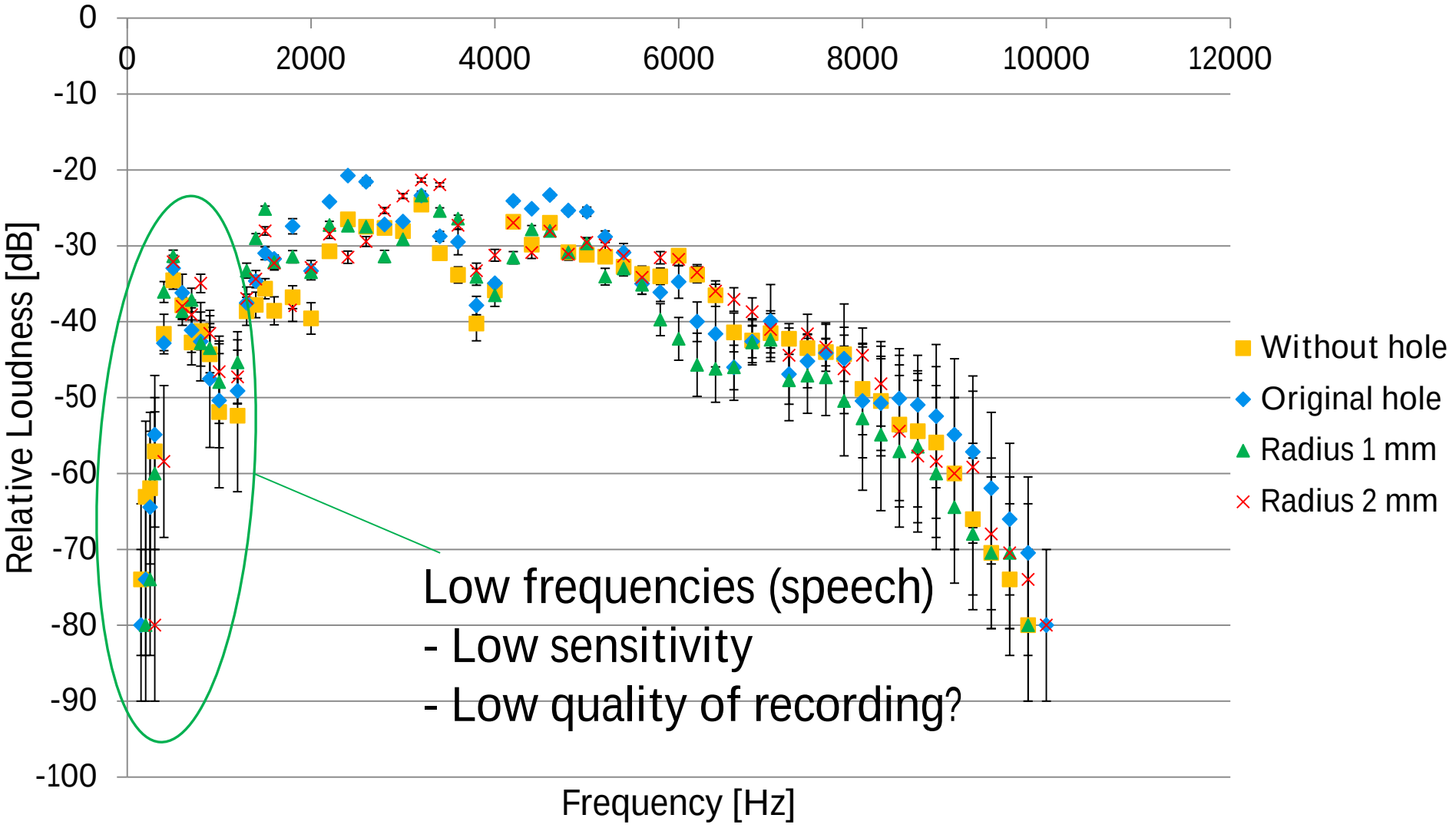
Frequency response at 94 dB - hole effect



Frequency response at 94 dB - hole effect

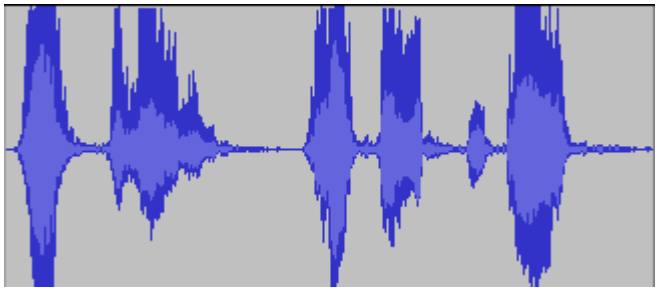


Frequency response at 94 dB - hole effect



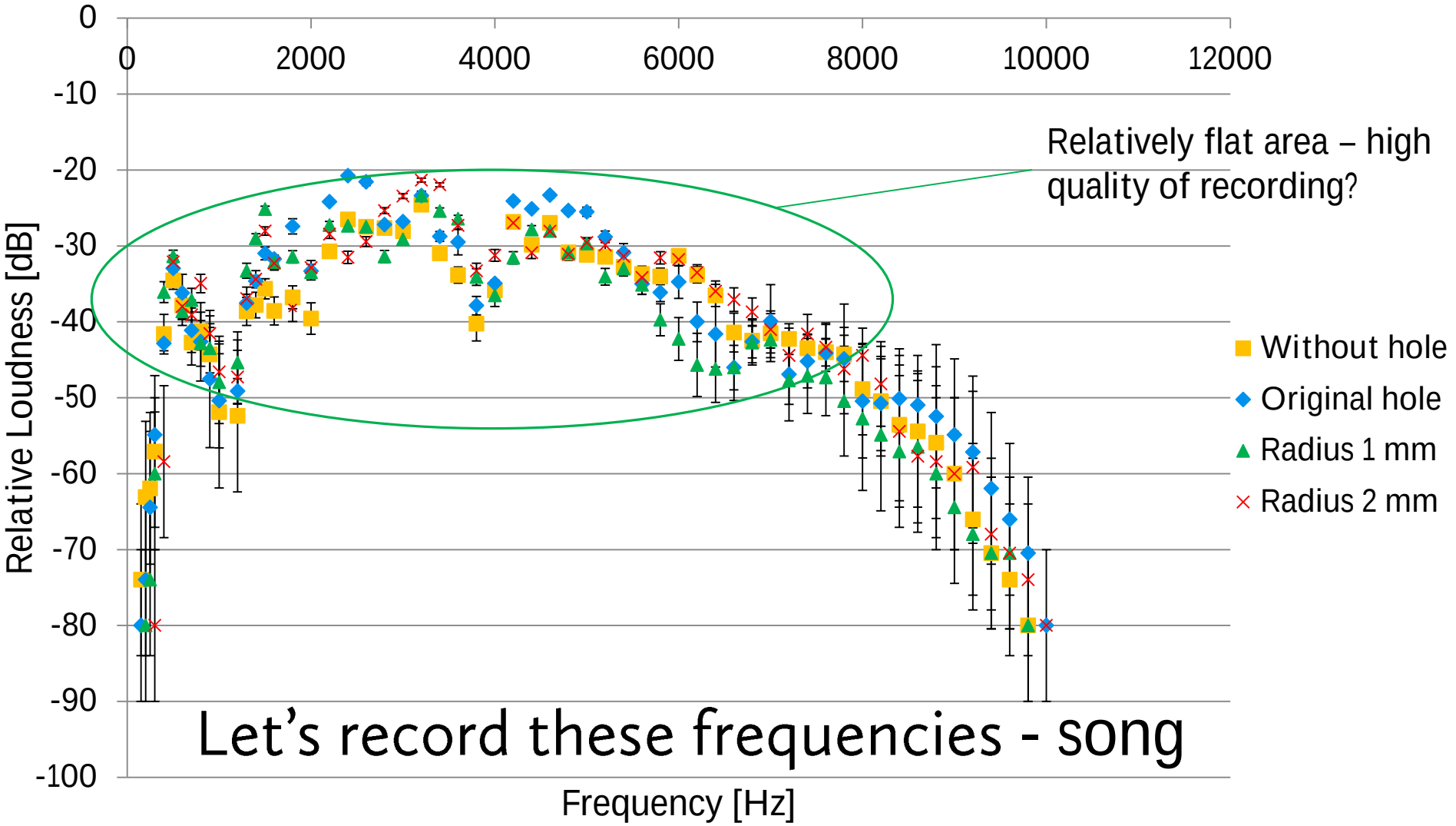
Hi, how are you...? Speech record

Factory made microphone



Actually, not that bad !

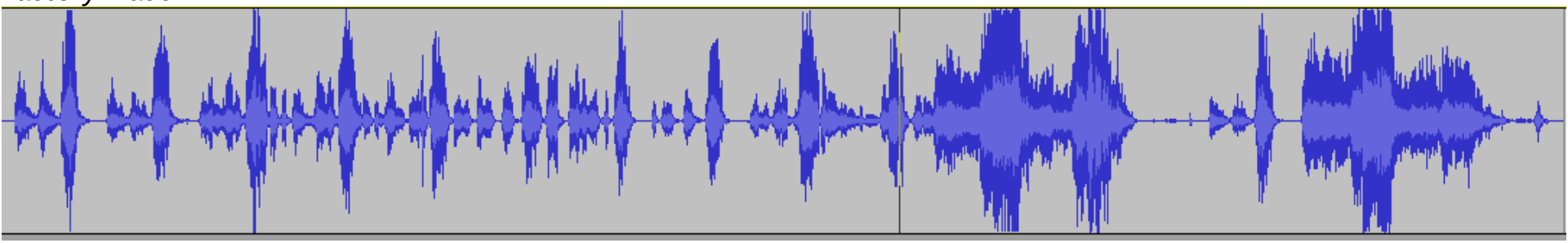
Frequency response at 94 dB - hole effect



Song record

Factory assembled
R=100Ω

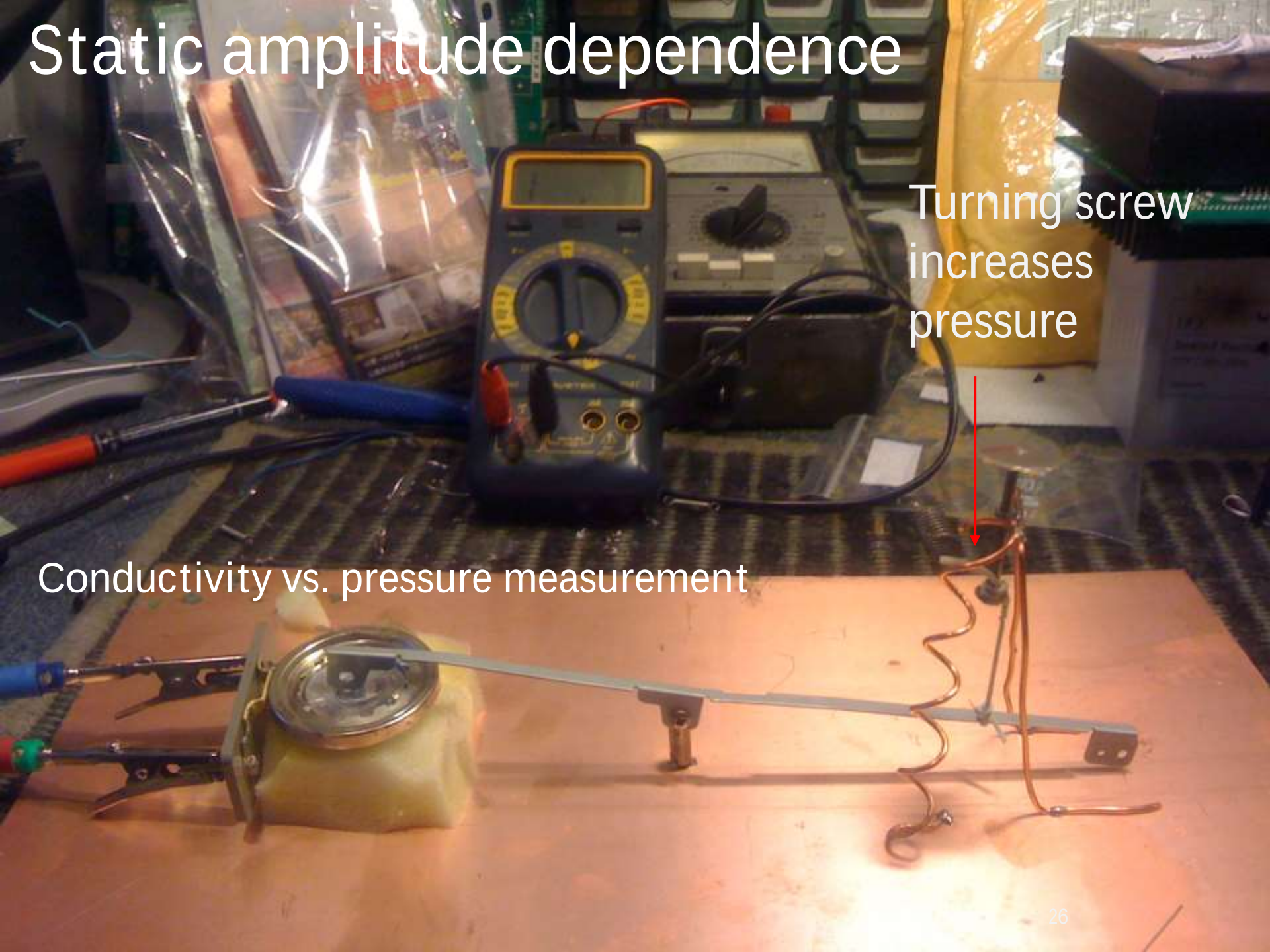
Factory made



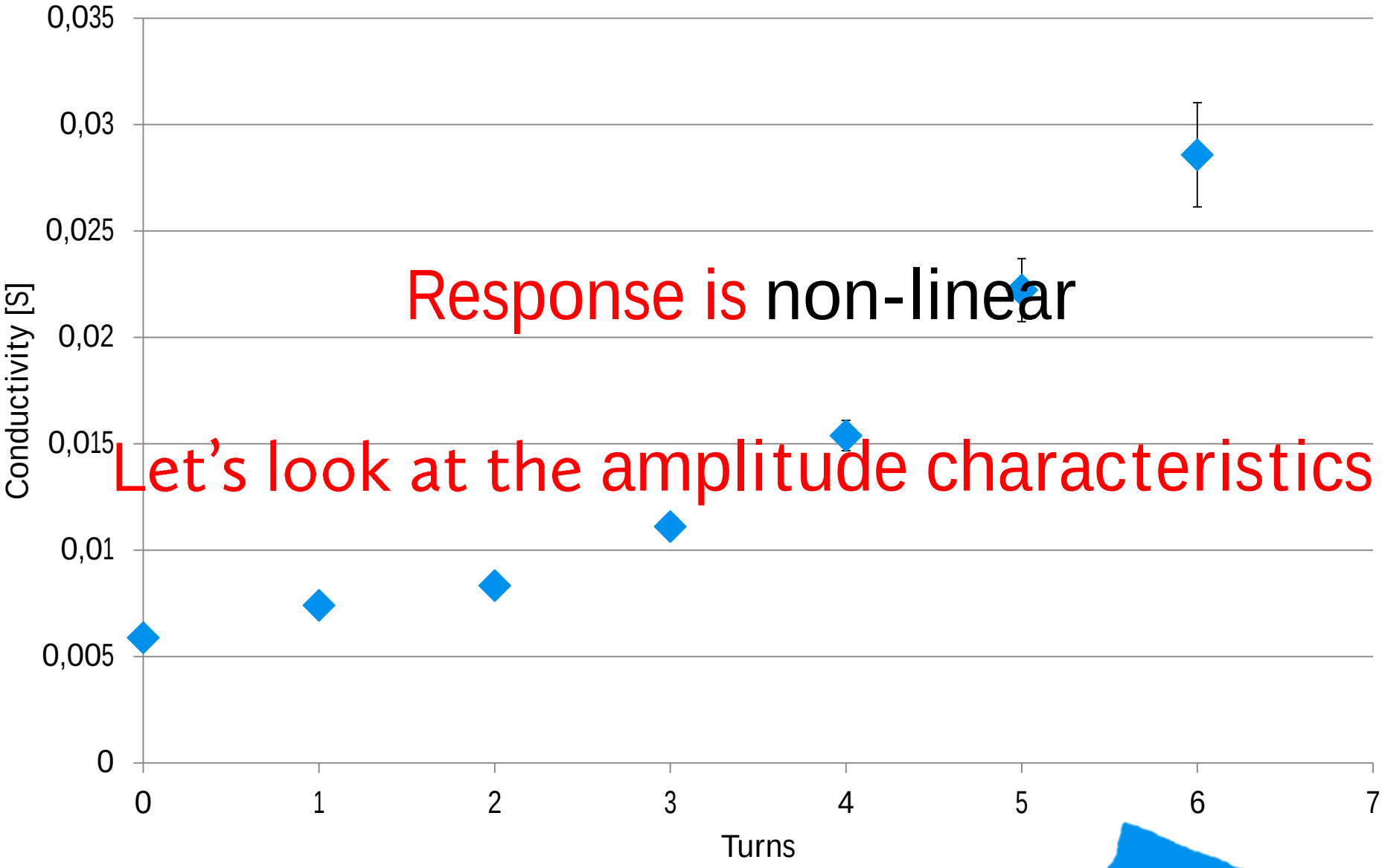
Song has significantly worse quality
How is it possible?
Wide range of frequencies
possibly irregular input from microphone – different amplitude response

Let's investigate amplitude dependence of microphone

Static amplitude dependence



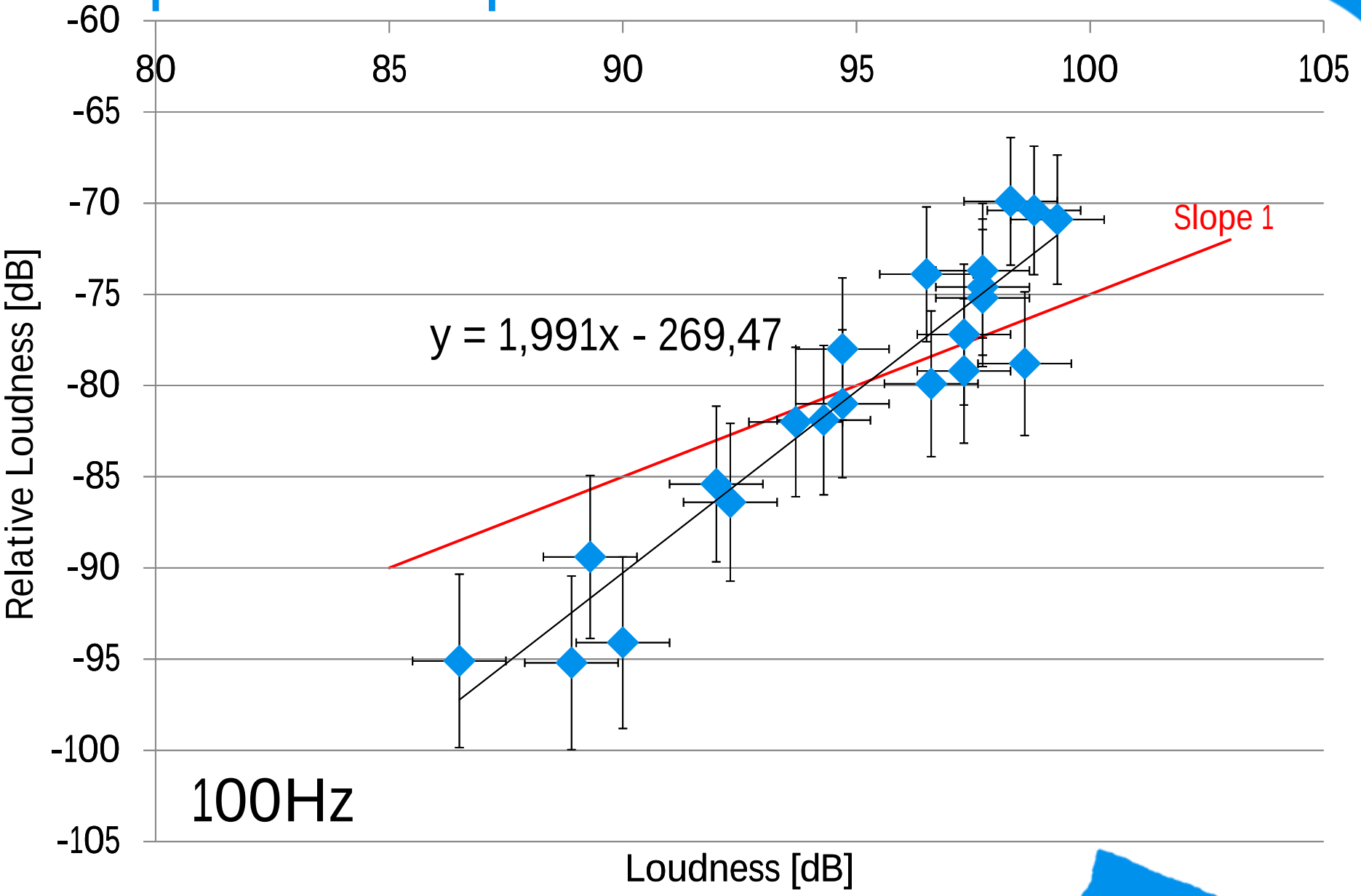
Static amplitude dependence



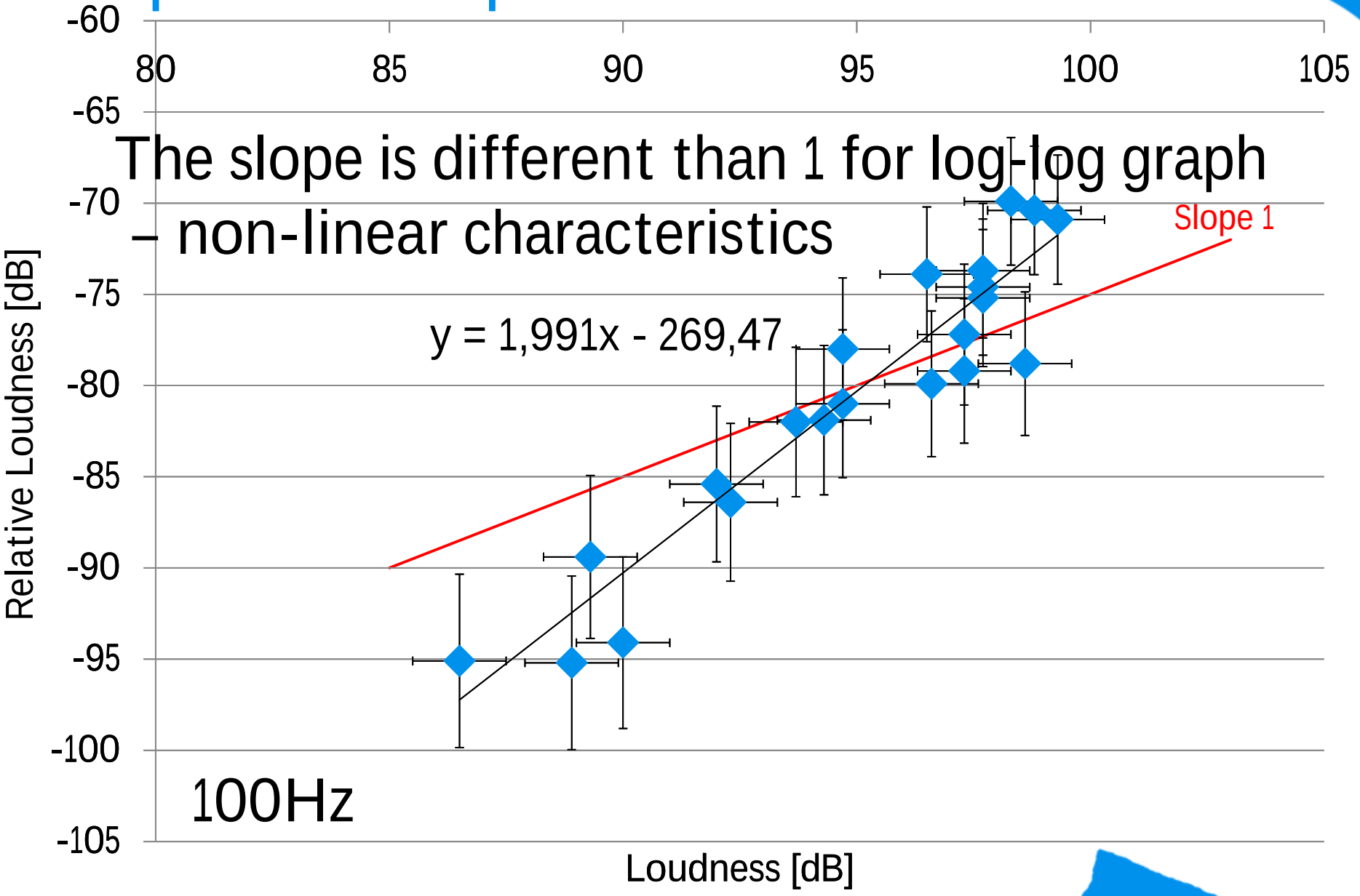
Response is non-linear

Let's look at the amplitude characteristics

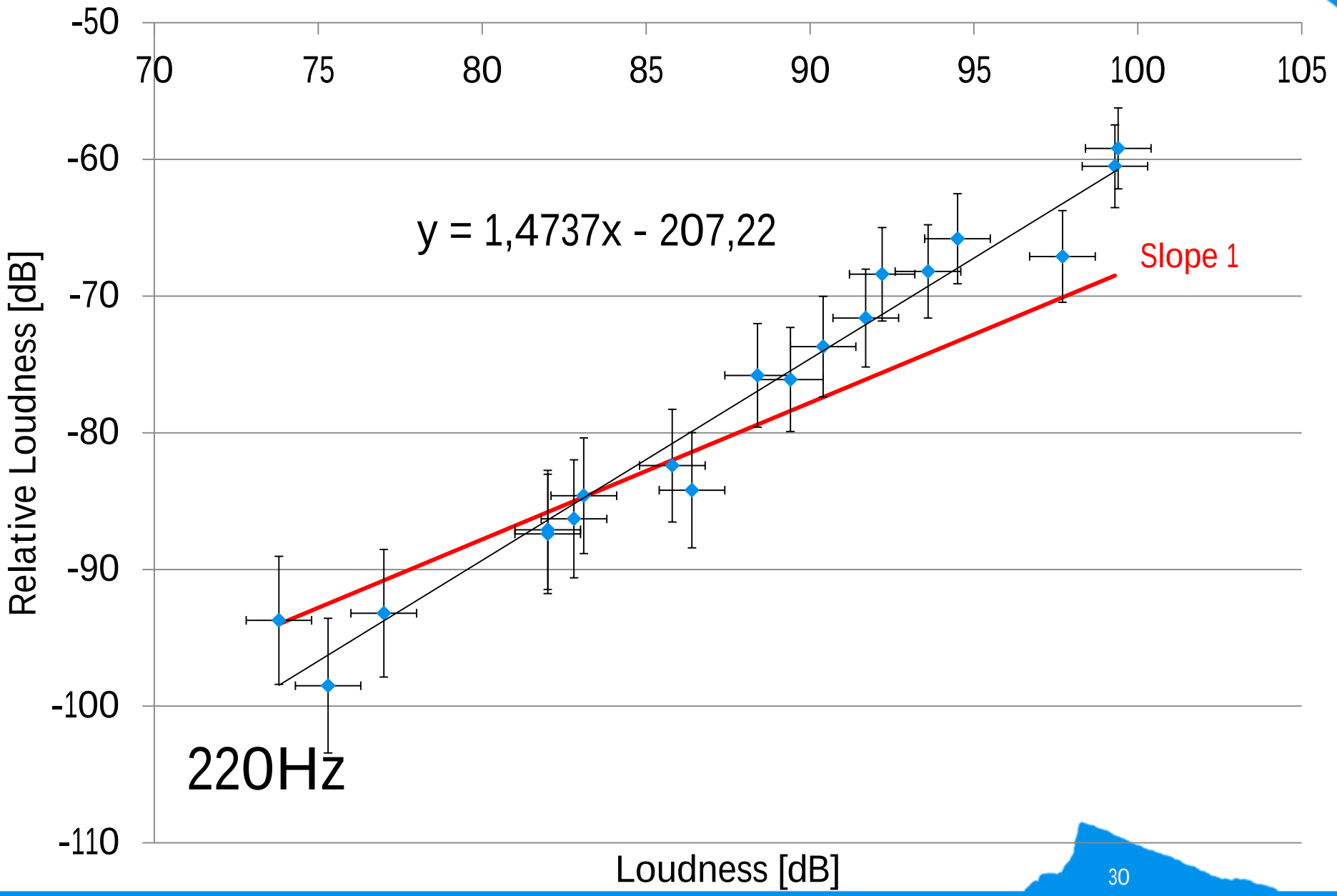
Amplitude response characteristics



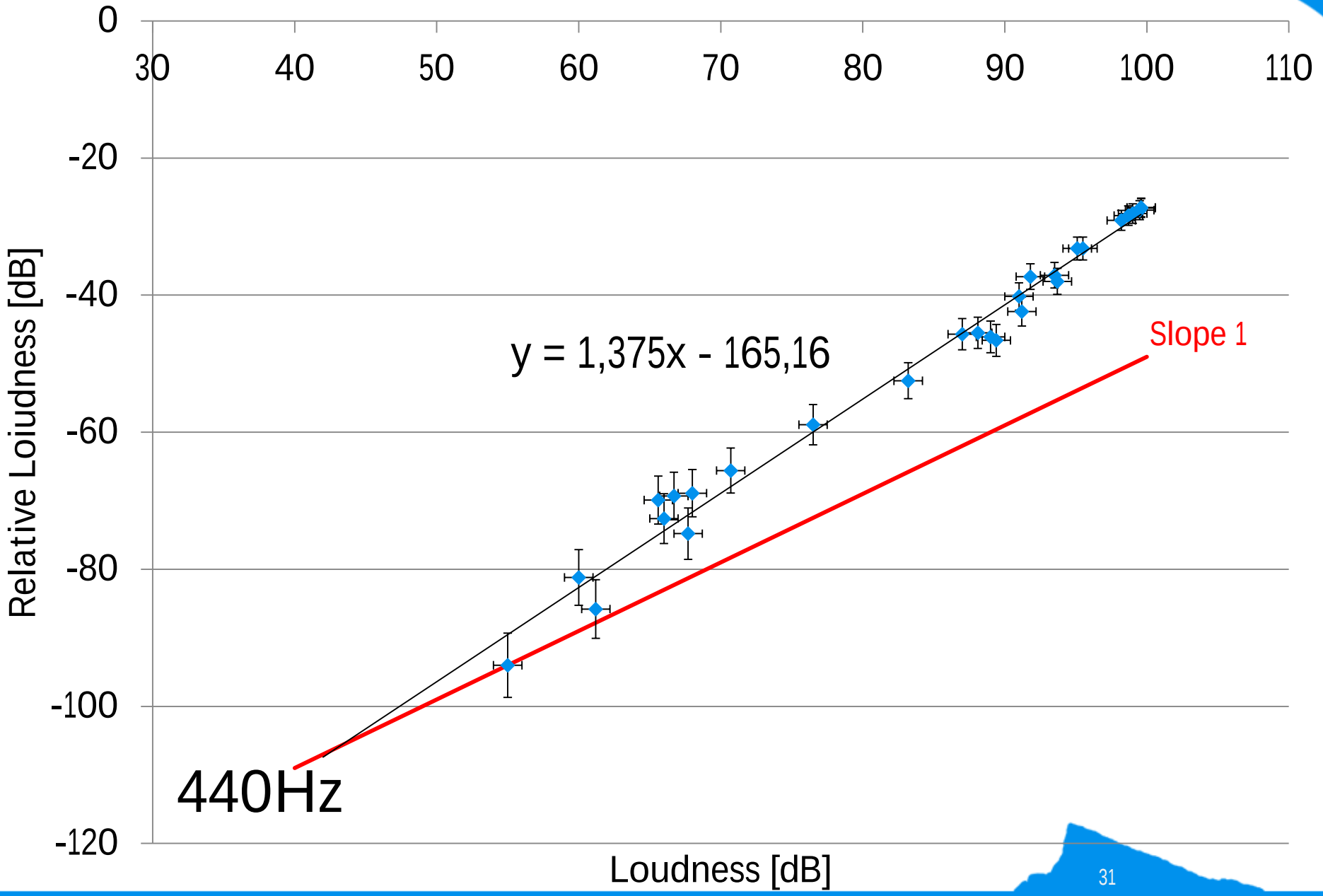
Amplitude response characteristics



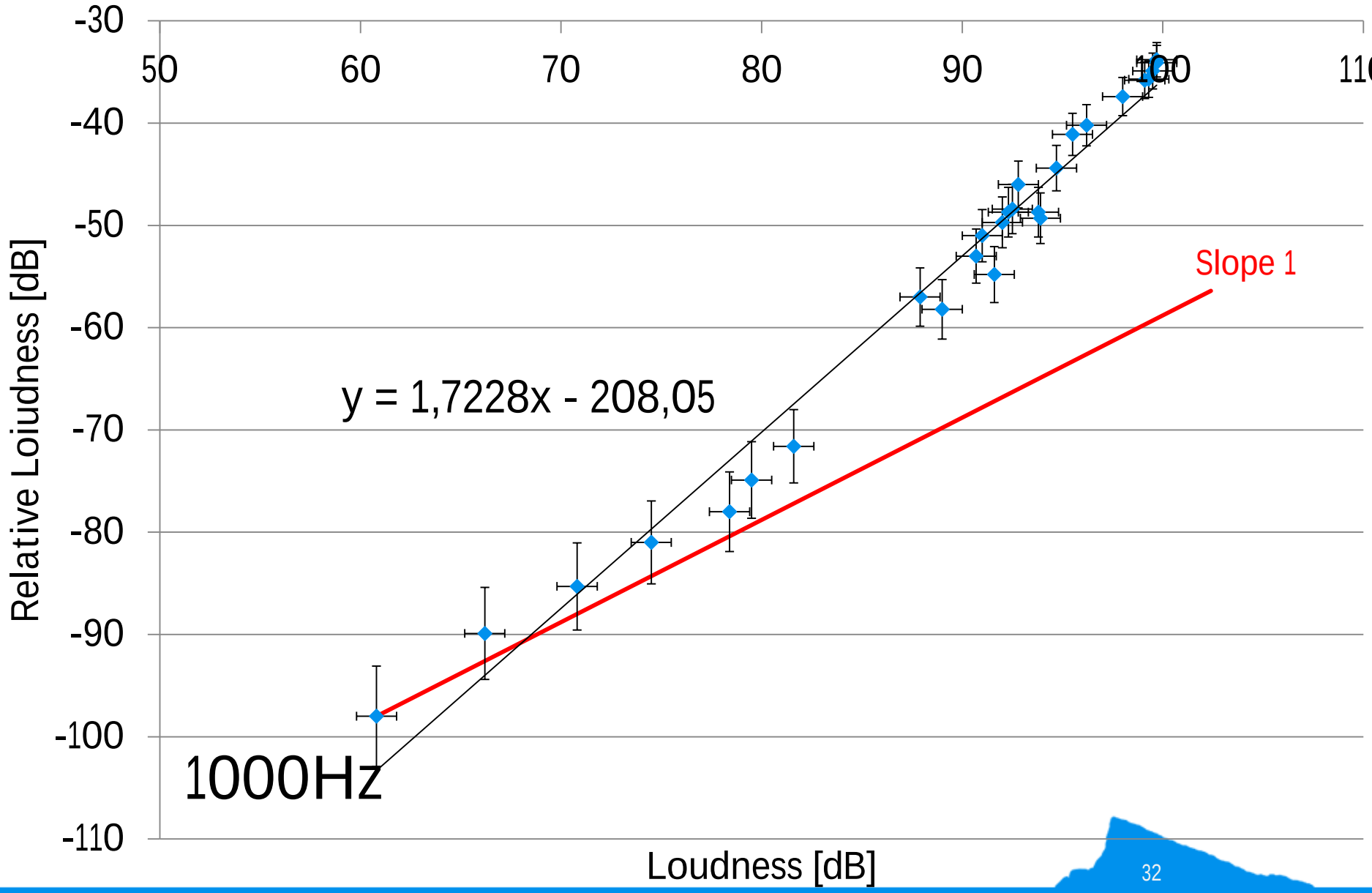
Amplitude response characteristics



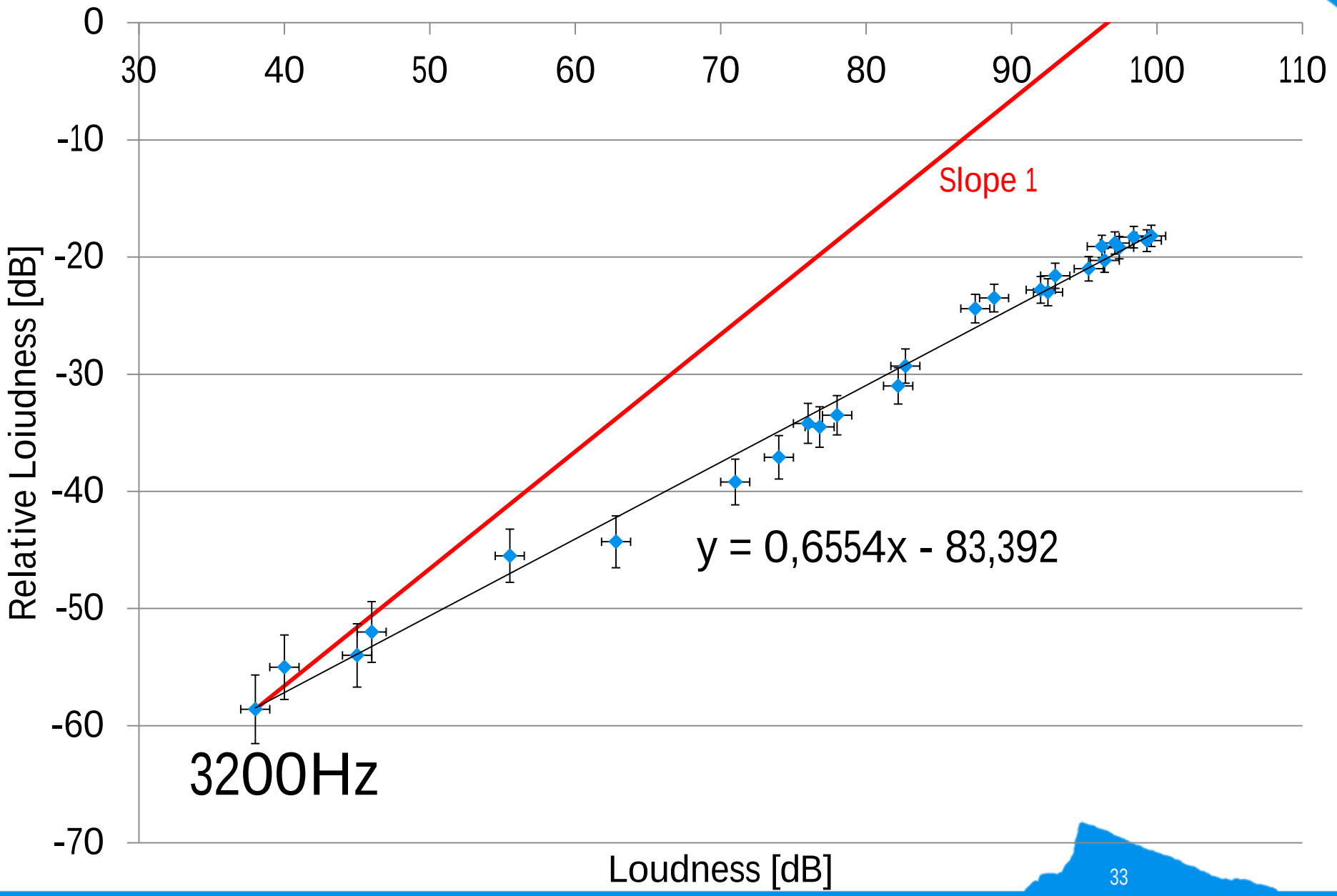
Amplitude response characteristics



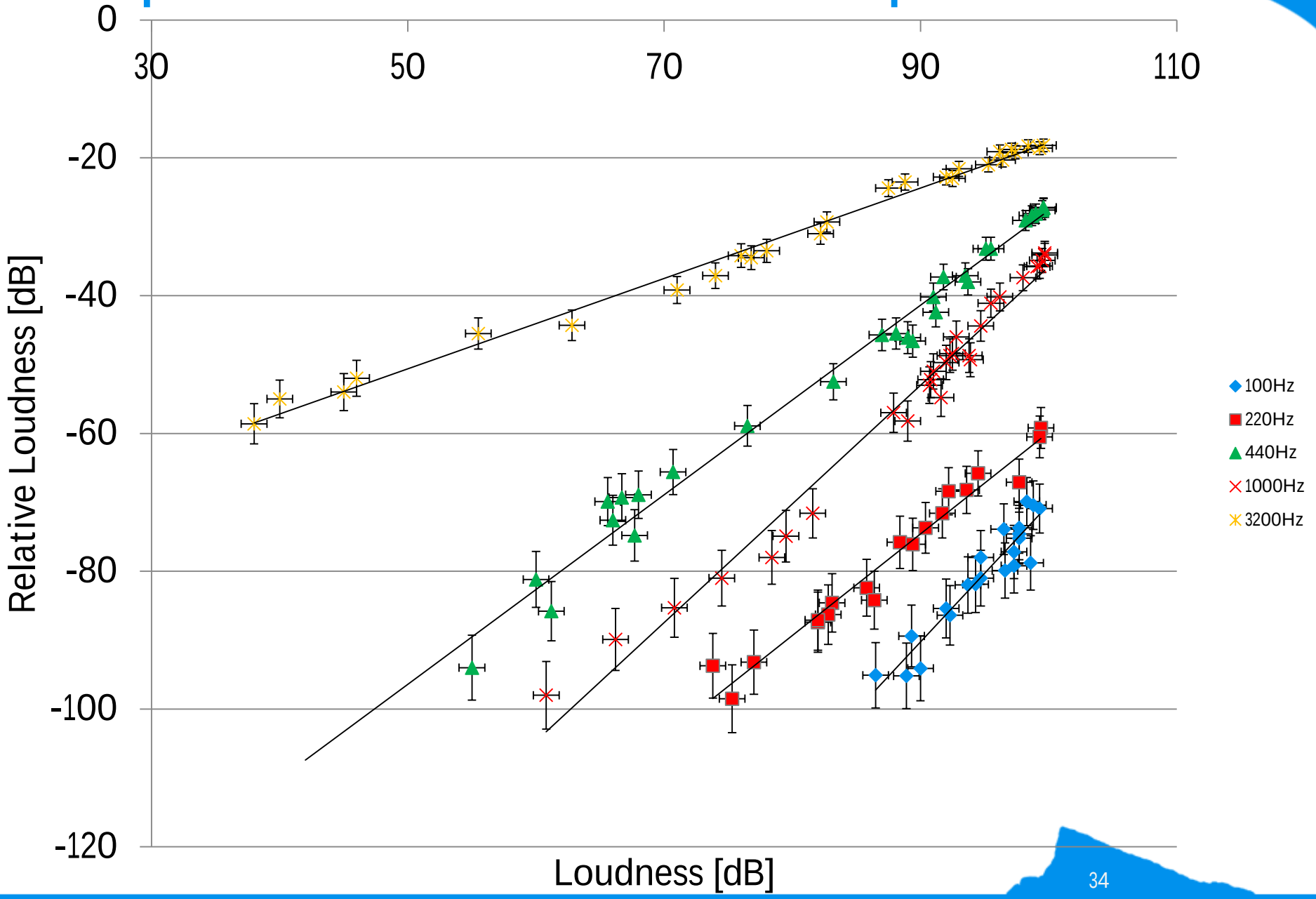
Amplitude response characteristics



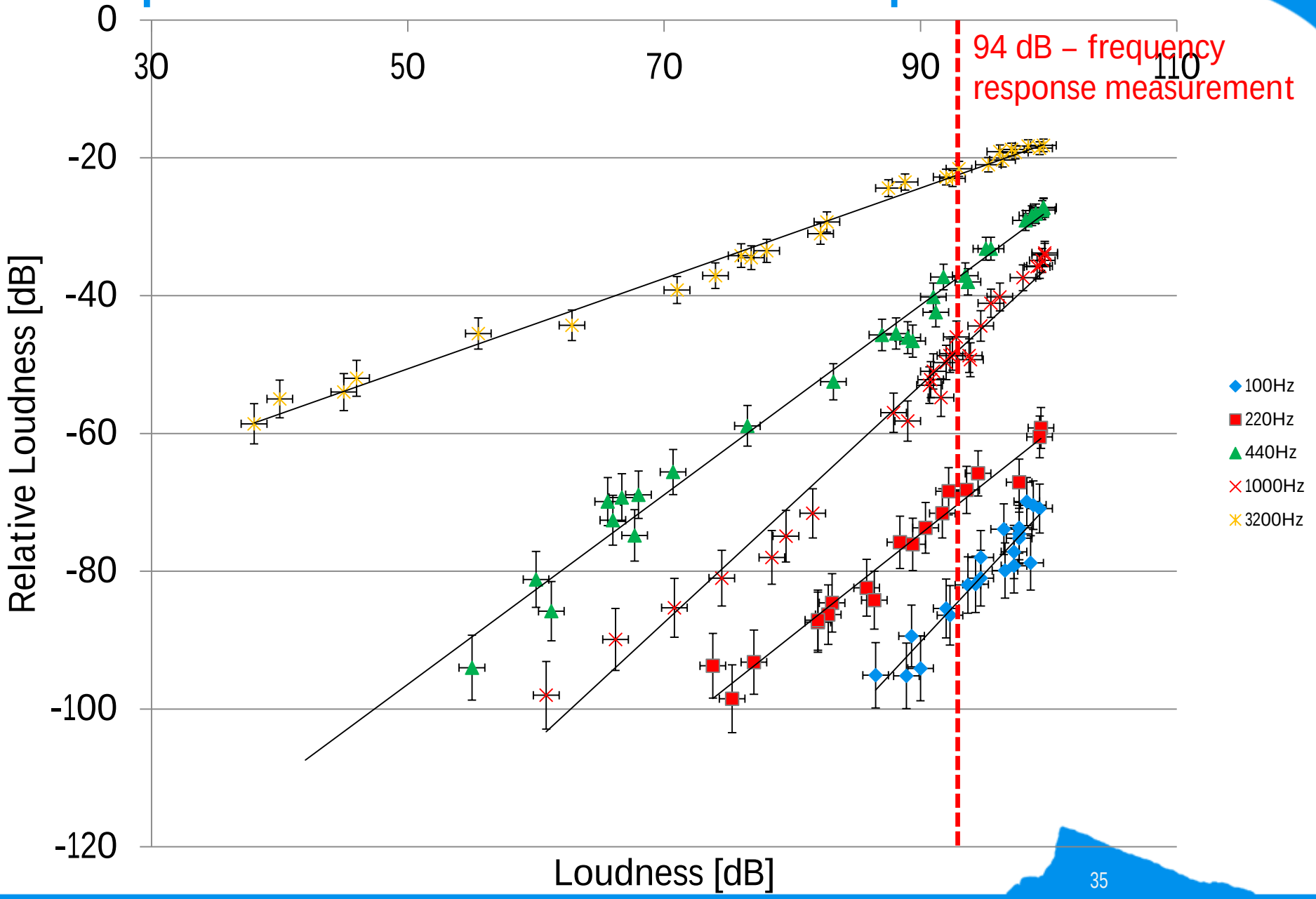
Amplitude response characteristics



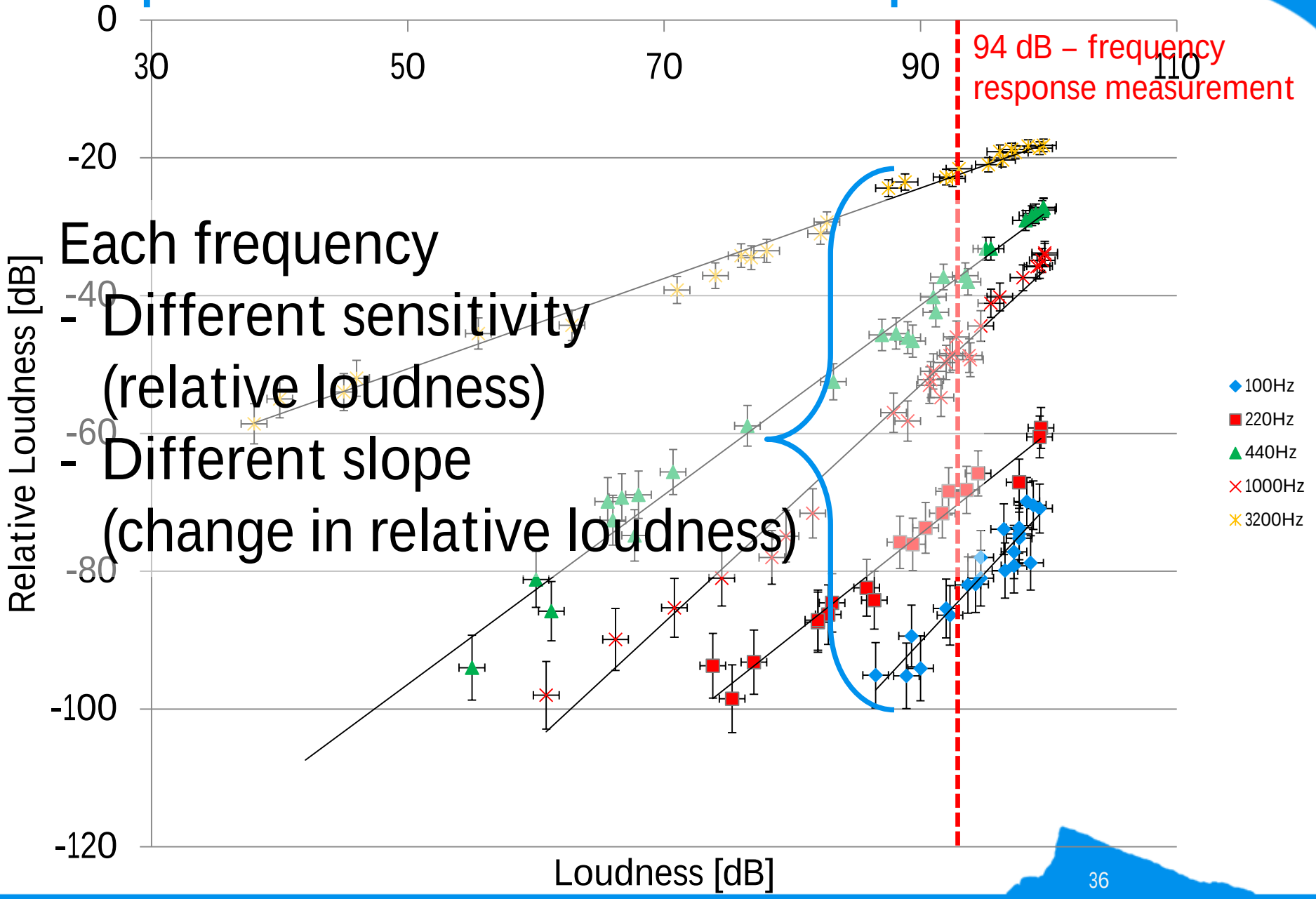
Comparison for different frequencies



Comparison for different frequencies

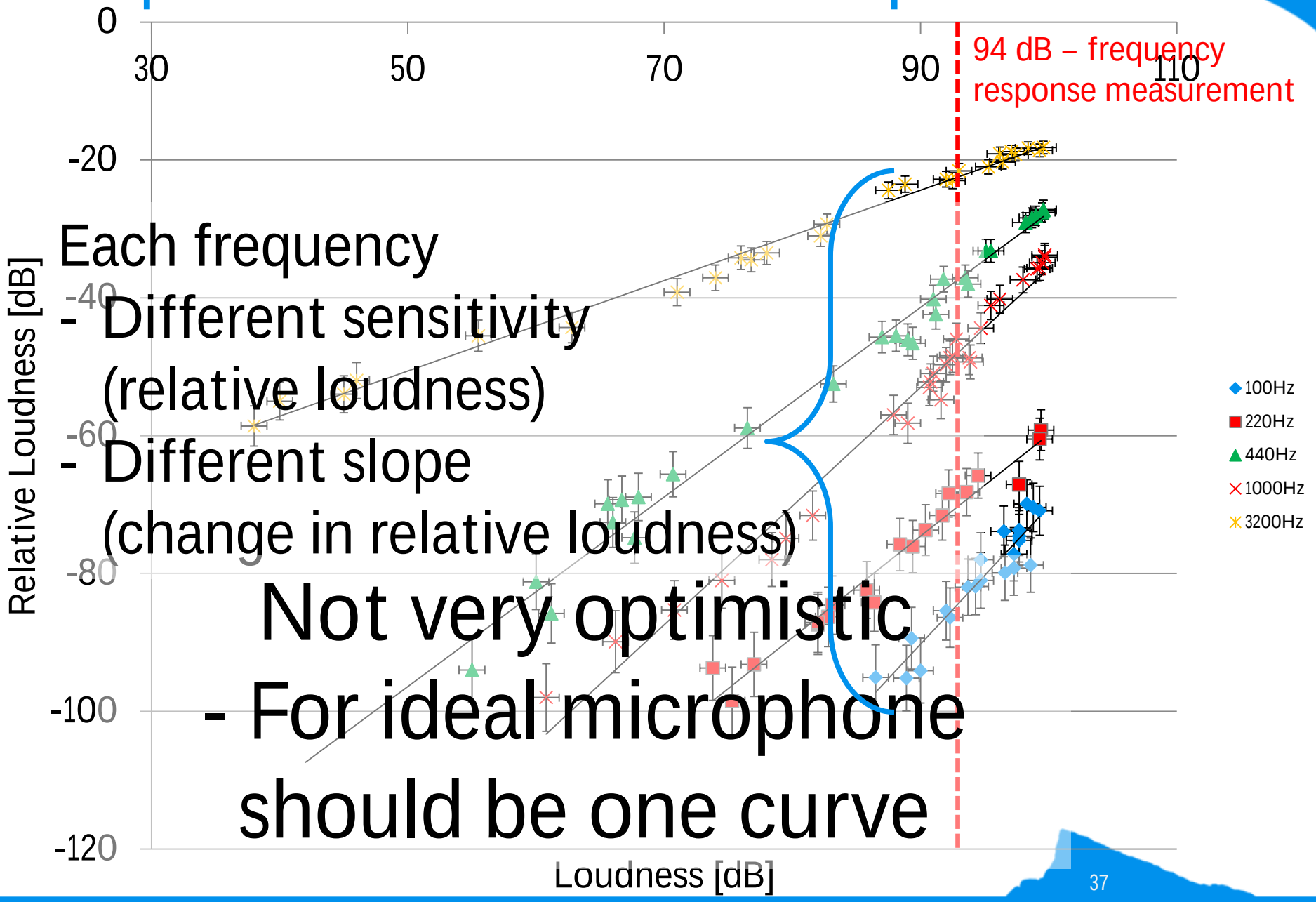


Comparison for different frequencies



Each frequency
- Different sensitivity (relative loudness)
- Different slope (change in relative loudness)

Comparison for different frequencies



Each frequency
- Different sensitivity (relative loudness)
- Different slope (change in relative loudness)

Not very optimistic
- For ideal microphone should be one curve

Why is sound distorted?

- Speech – narrow range of frequencies
  - sound card will adapt its sensitivity

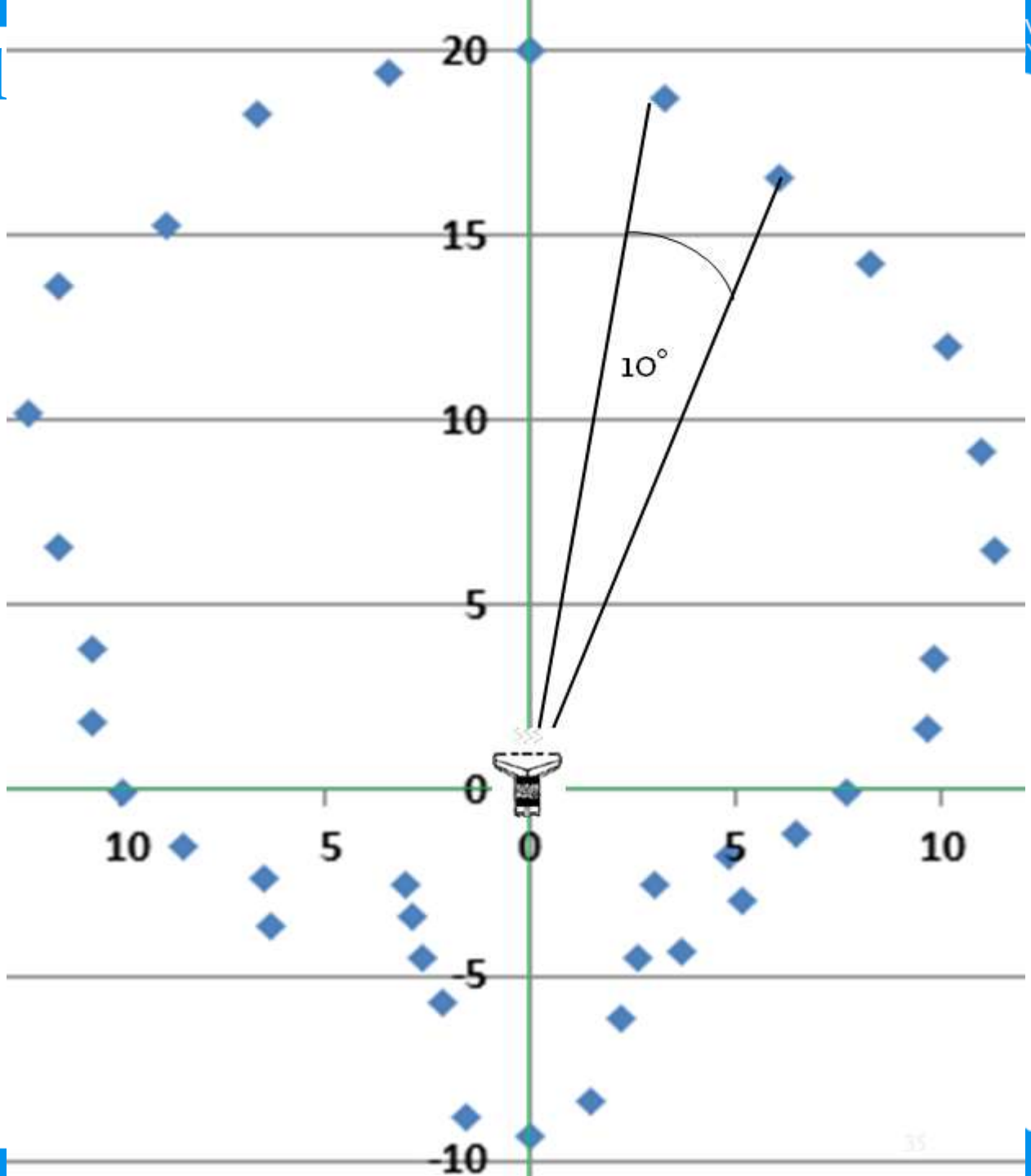
- Song – wide frequency span – great variation in relative loudness – sound card unable to adapt its sensitivity

Microphone can be used only to narrow range of frequencies (speech) – due to its non-linearity

Directional pattern

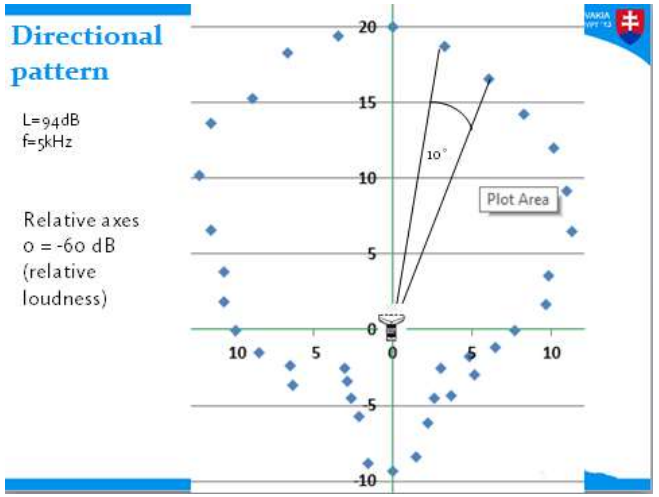
L=94dB
f=3200Hz

Relative axes
0 = -60 dB
(relative loudness)



Thank you for your attention

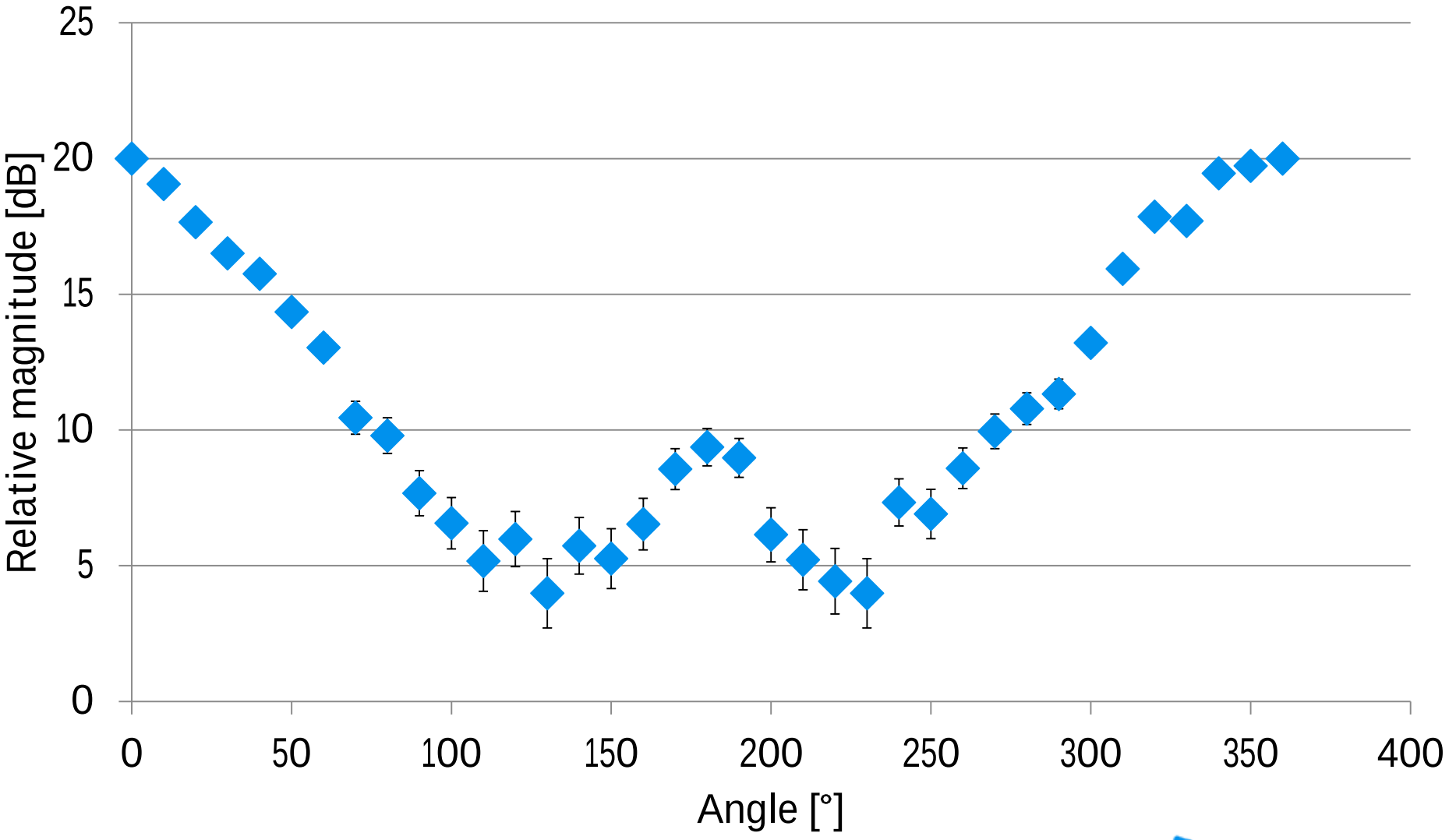
- ✓ Explained the principle
- ✓ Investigated components of microphone
- ✓ Our own microphone ☺
- ✓ Characteristics of microphone
  - ✓ Frequency response
  - ✓ Investigated the 'hole' effect
  - ✓ Amplitude response
    - Narrow range
  - ✓ Direction



APPENDICES

Thanks to Martin Ferianc for technical support

Directional – relative magnitude



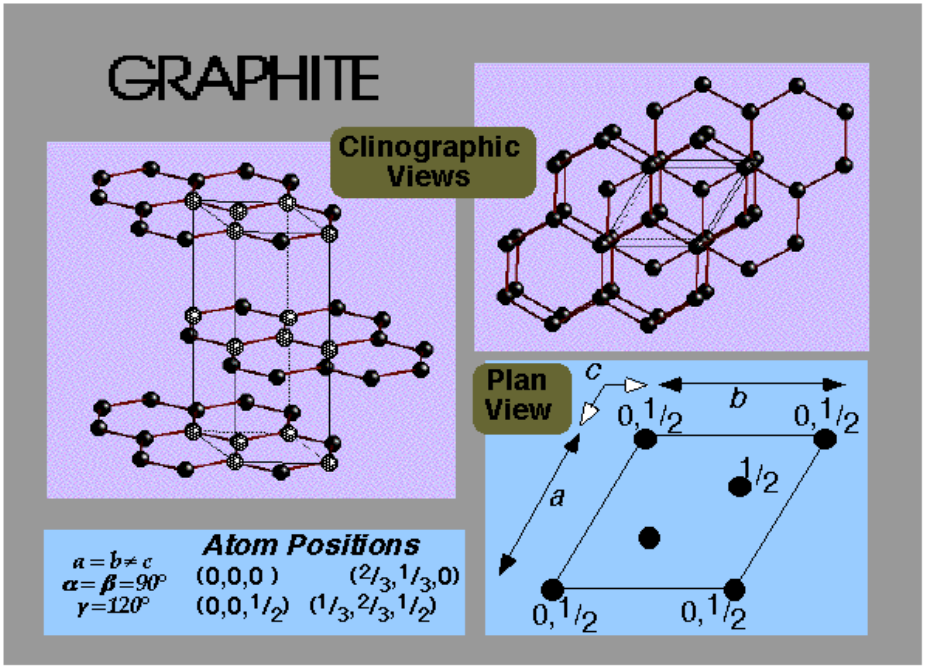
Carbon Powder

Graphite – is a very bad conductor !

big changes in resistance

Idealy no add. Substances

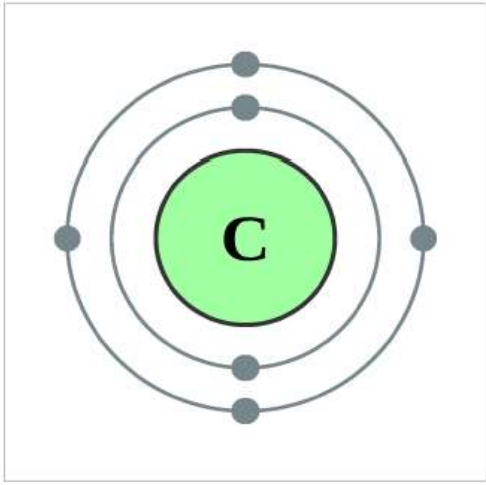
Van der Waals (170 pm)



Group, period, block

14, 2, p

2, 4 Electron configuration



Carbon Powder

Stable

Triple point is at

10.8 ± 0.2 MPa

4,600 ± 300 K

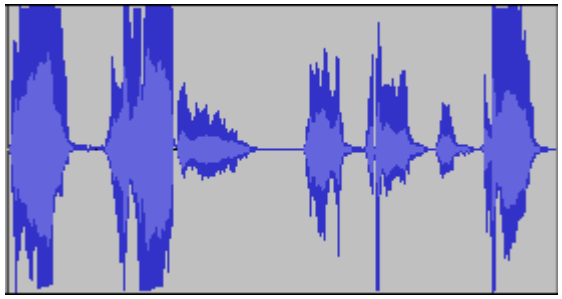
Sublimates at 3,900 K.

Carbon powder of the carbon microphone

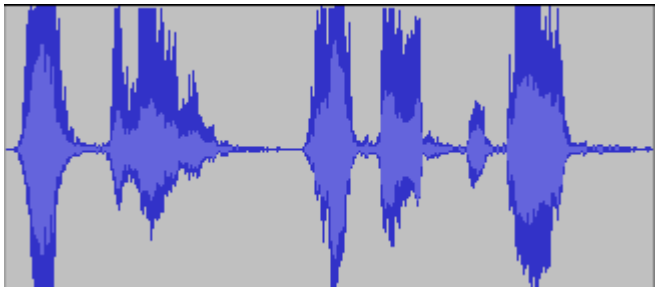

Chamber with carbon grains
Membrane
Resistor
Voltage source

Hi, how are you...?

Home made



Factory made



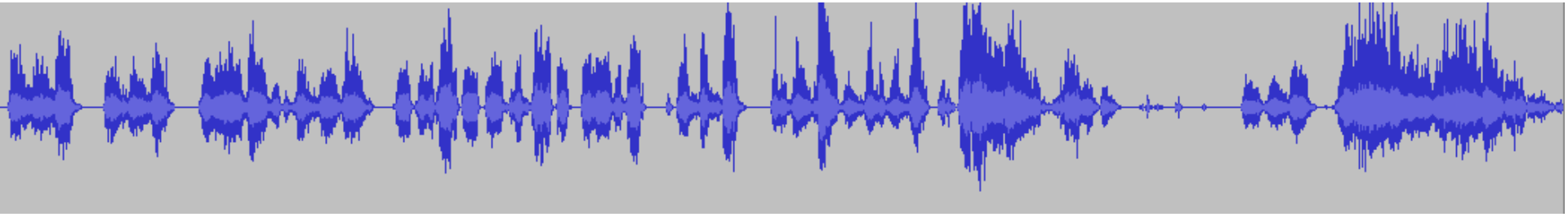
Factory records speech better – small range of frequencies – what about song?

Comparison

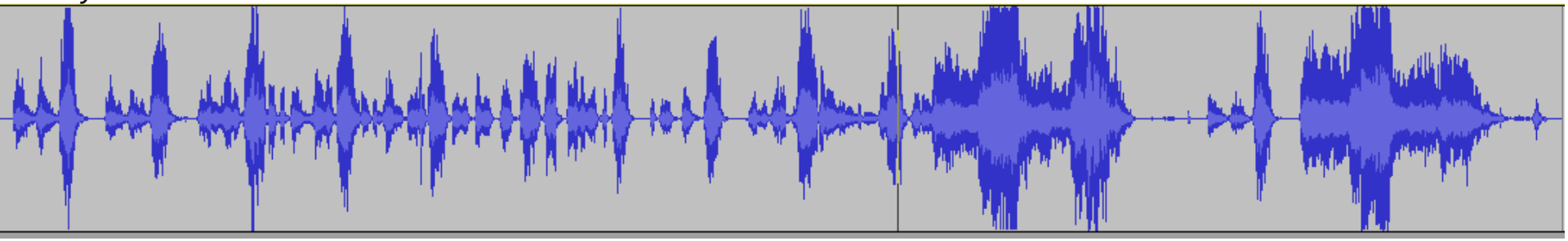
Home made
R=5000Ω

Factory assembled
R=100Ω

Home made



Factory made



The record of the song with factory made has similar 'quality' as with home made – as predicted by its characteristics