

Measuring Headphone Frequency Response

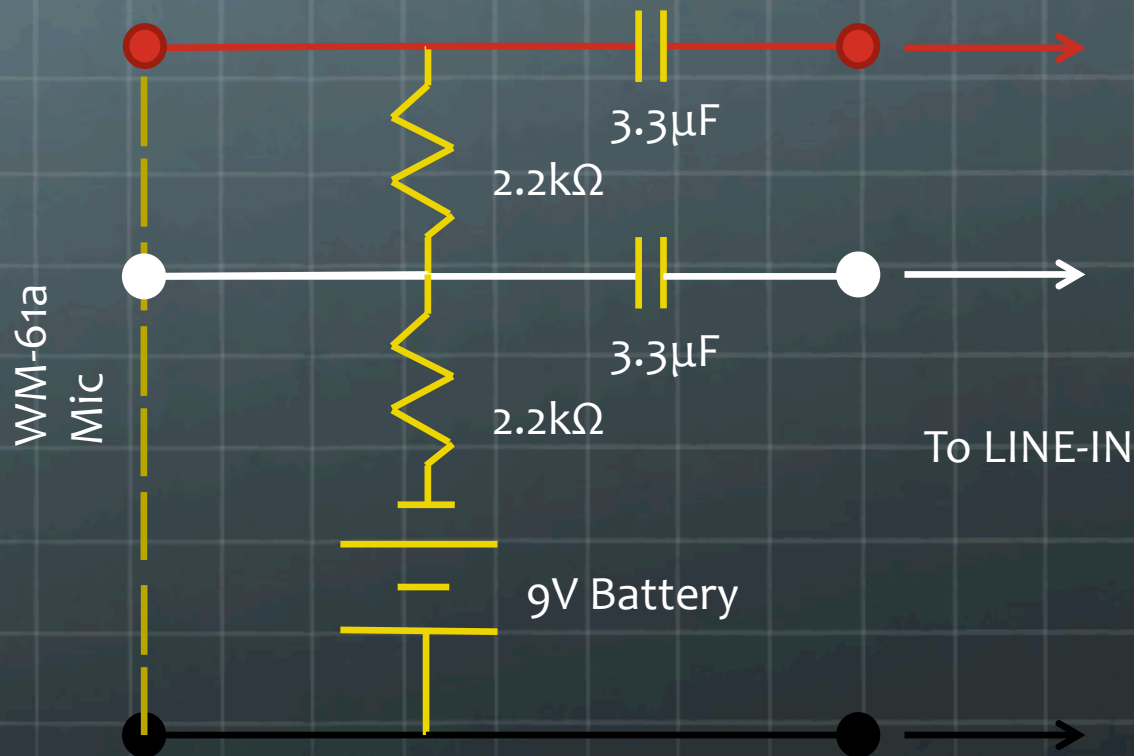
Werner Dahm

The Basics

- 🌐 **Tools and Equipment you'll need to measure headphone response**
 - 🌐 **REW: Room Equalization Wizard**
 - 🌐 **M3DMixer only for OS X 10.6 and older (10.7 doesn't need it)**
 - 🌐 **Phantom Power Supply (9V)**
 - 🌐 **Panasonic WM-61a electret capsule mic**
 - 🌐 **One or two RCA male to 1/8" female cables**
 - 🌐 **One male 1/8" TRS to male 1/8" TRS cable**
 - 🌐 **Headphones to measure**

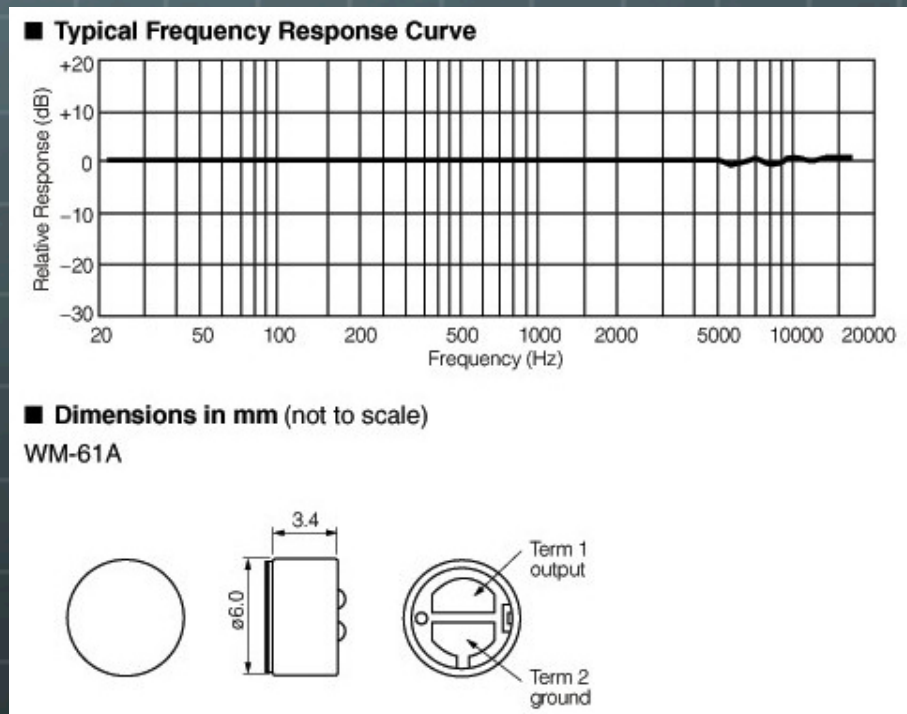
Phantom Power Supply

- Using a reference schematic from a friend, determined the correct components



Mic calibration

- Since the Panasonic WM-61a is a well-regarded measurement electret capsule mic, it has its own calibration file readily available online



The screenshot displays the REW (Room EQ Wizard) software interface. A 'Preferences' dialog box is open, showing the 'Calibration' tab. The 'Type' section has the 'C Weighted SPL Meter' checkbox checked, and the 'File' field contains 'WM-61A.frd'. The 'Help' section contains the following text:

Type

Select the **C Weighted SPL Meter** check box if you are using a C weighted SPL meter as the input to REW, measurements will then be corrected to remove the low and high frequency roll-offs of the C weighting characteristic. If a cal file is loaded the correction will only be applied outside the frequency range covered by the cal file.

Calibration

If you have a calibration data file for your SPL meter or microphone you can load the data into REW by clicking the **Browse** button. The calibration data will be applied to all new measurements taken after it has been loaded and will be shown on the SPL & Phase graph for the measurements. To remove the calibration data file click the **Clear Cal** button.

To apply or remove a calibration file for an existing measurement, use the **Change Cal...** button in the measurement panel.

To calibrate the REW SPL meter reading against an external meter use the **Calibrate** button in the SPL Meter controls.

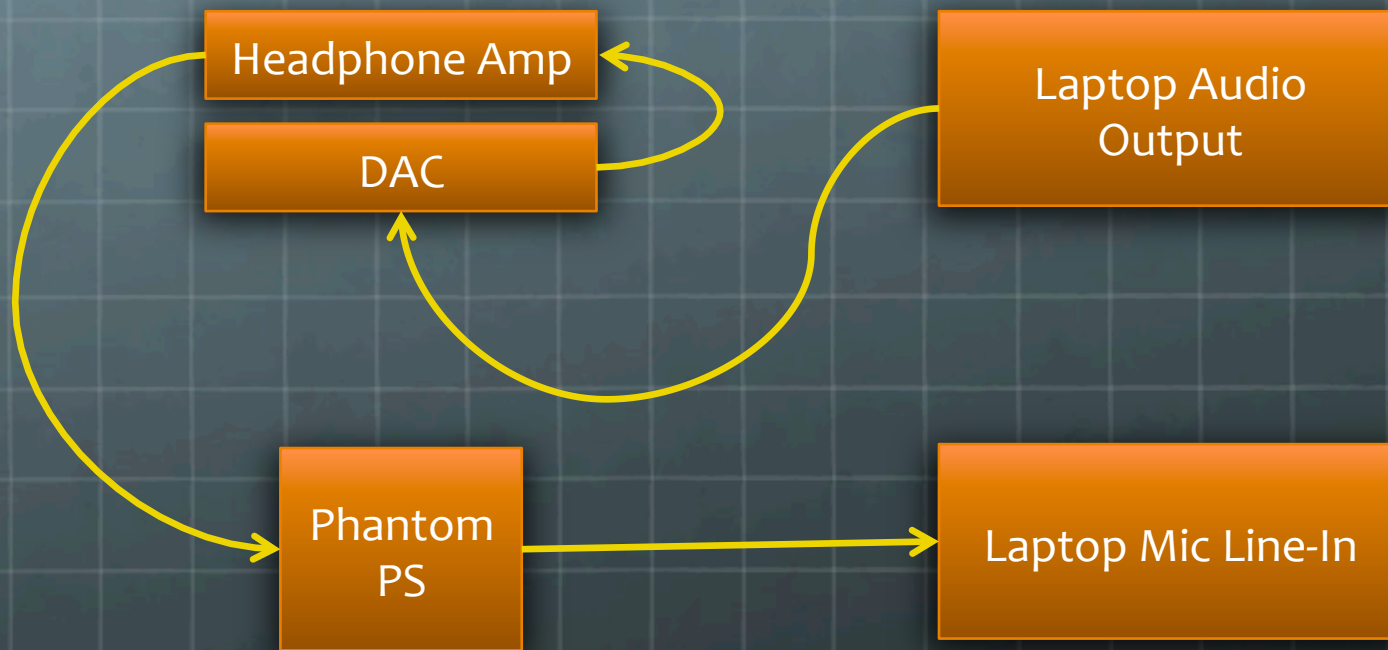
The background shows the main REW interface with a frequency response graph. The graph has a logarithmic x-axis from 2 Hz to 30.0k Hz and a y-axis from -35 dB to 100 dB. Two curves are plotted: a blue line for '1: Average 1' and a red line for '2: Average 1'. Both curves show a similar response with a peak around 10k Hz. The 'Average the Responses' button is highlighted at 3.80 Hz. The system tray at the bottom shows various icons, including the REW logo, and the system clock indicates 'Thu 7:54 AM'.

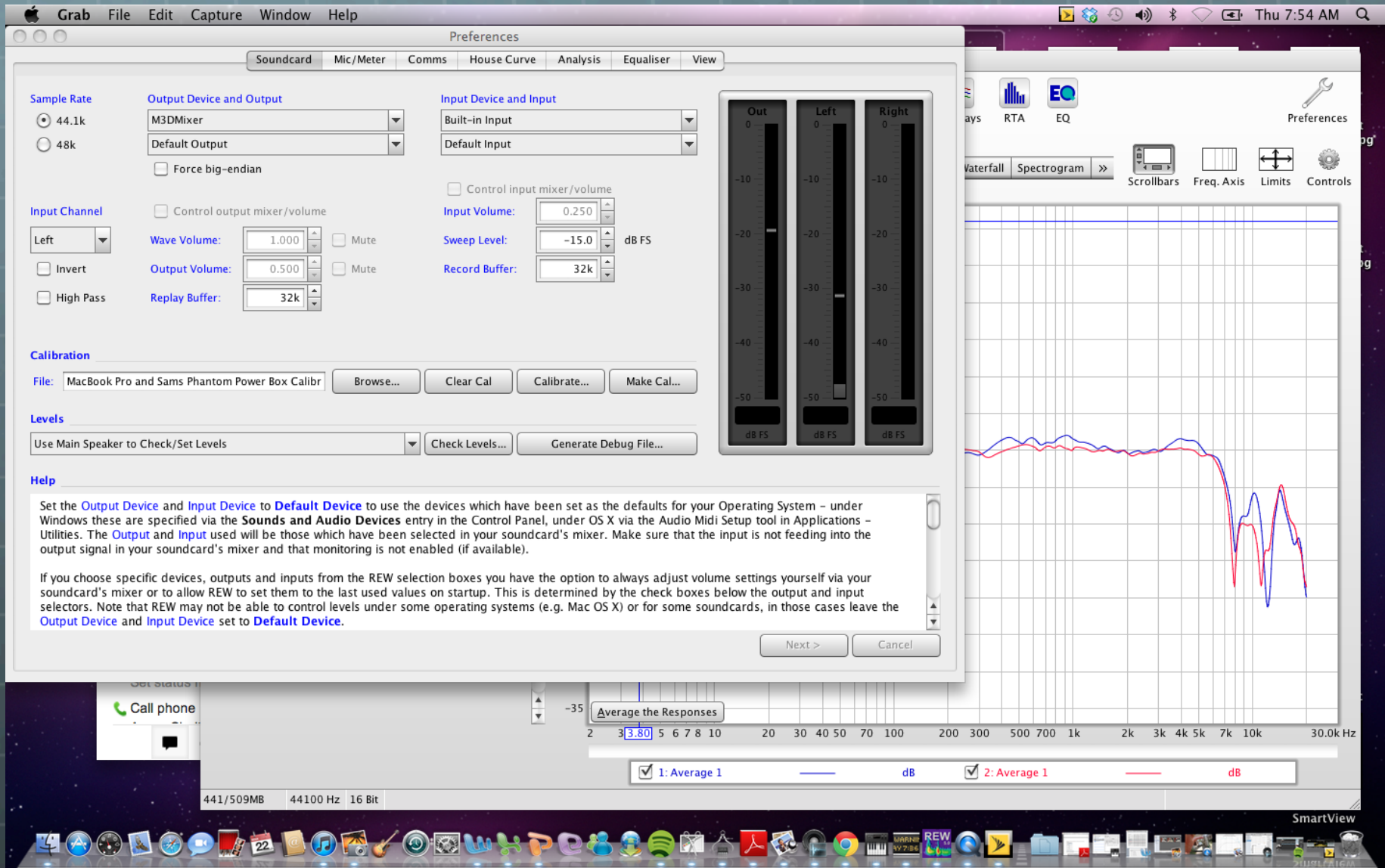
Screenshot from Keith Atkins

REW

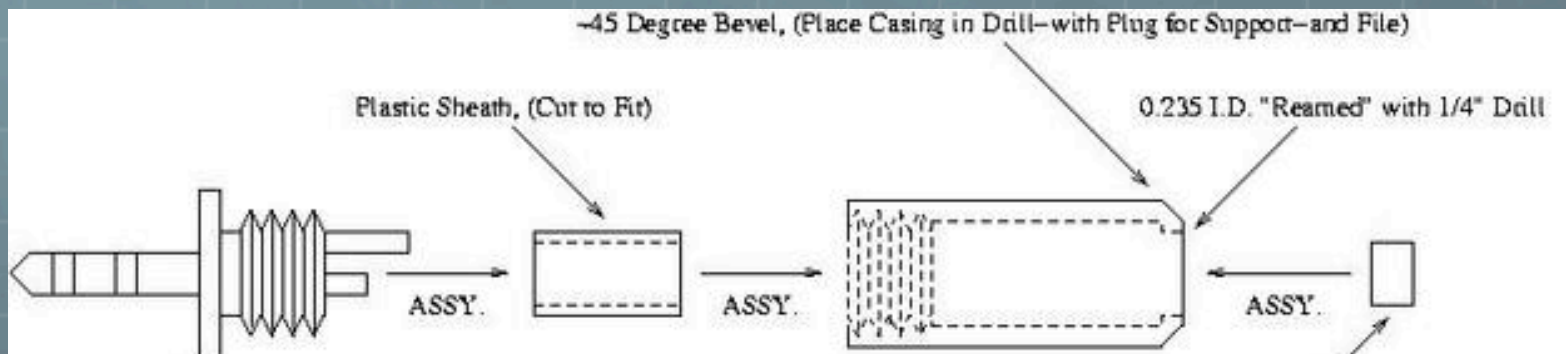
- Before measurements are accurate, the user must calibrate their recording system
 - Includes everything before the headphones and mic
 - DAC/Soundcard
 - Amp
 - Phantom power supply
- We do this calibration by creating a feedback loop and using the software to make corrections to account for non-linearity in the system

Feedback Loop





Screenshot from Keith Atkins



NOT TO SCALE

3.5 mm Stereo Plug
 (Ground Pin Cut to Minimum Length Practical)
 (Tip and Ring Soldered, and Connected to "Hot" of WM61A;
 Shank Connected to "Cold" of WM61A, Through Casing)

Panasonic WM61A, O.D. = 6 mm = 0.2362", Height = 4 mm
 (Clearance = 0.25 - 0.2362 = 13.8 Mills, 0.0069 Mills in Radius)
 (Note: 0.235 I.D. is Probably 15/64 = 0.2344; 1.8 Mill Press Fit)
 (Note: -5/16" Clearance Between Plastic Sheath and WM61A)

Bill of Materials:

- Panasonic WM61A = Digi-Key P9925-ND - \$1.86
- 3.5 mm Stereo Plug = Radio Shack 2740858, - \$3.99, (Strain Relief Discarded)
- 3.5 mm Stereo Plug = Neutrik NY8231G, Allied 514-8001, - \$1.39, (Alternative)
- 3.5 mm Stereo Plug = Neutrik NY8226, Allied 514-0024, - \$0.86, (Alternative)
- 3.5 mm Stereo Plug = Neutrik NY8231B, Allied 514-8003, - \$1.18, (Alternative)

Tooling:

1/4 Drill Bit = Vermont American 12743 - \$3.49

Note:

- "Hot" Wire Insulation Length = 0.455"
- "Cold" Wire Insulation Length = 0.320"
- Cut and Tin Prior to Assembly

Taking Measurements

- 🌐 Connect the mic to the left channel of the RCA to 1/8" male cable
- 🌐 Connect this cable to the input (mic) side of the phantom power supply
- 🌐 Connect the 1/8" male to male cable from the phantom power supply output to the mic line-in on the laptop
- 🌐 Hook up the headphones as if you were going to listen to music (Audio Out USB → DAC → Amp → Headphones)
- 🌐 Position the mic in your ear carefully, and place headphones on your head

Make a measurement

SPL Impedance

Measure using 256k log sweep from DC to 20,000Hz at -15.0 dB taking 5.9 s

Start Freq (Hz)	End Freq (Hz)	Level (dB FS)	Length	Sweeps	Total Time
10	20,000	-15.0	256k	1	5.9s

Check Levels Start Measuring Cancel

Ready to measure...

0%

Out Left Right

0 -10 -20 -30 -40 -50

0 -10 -20 -30 -40 -50

0 -10 -20 -30 -40 -50

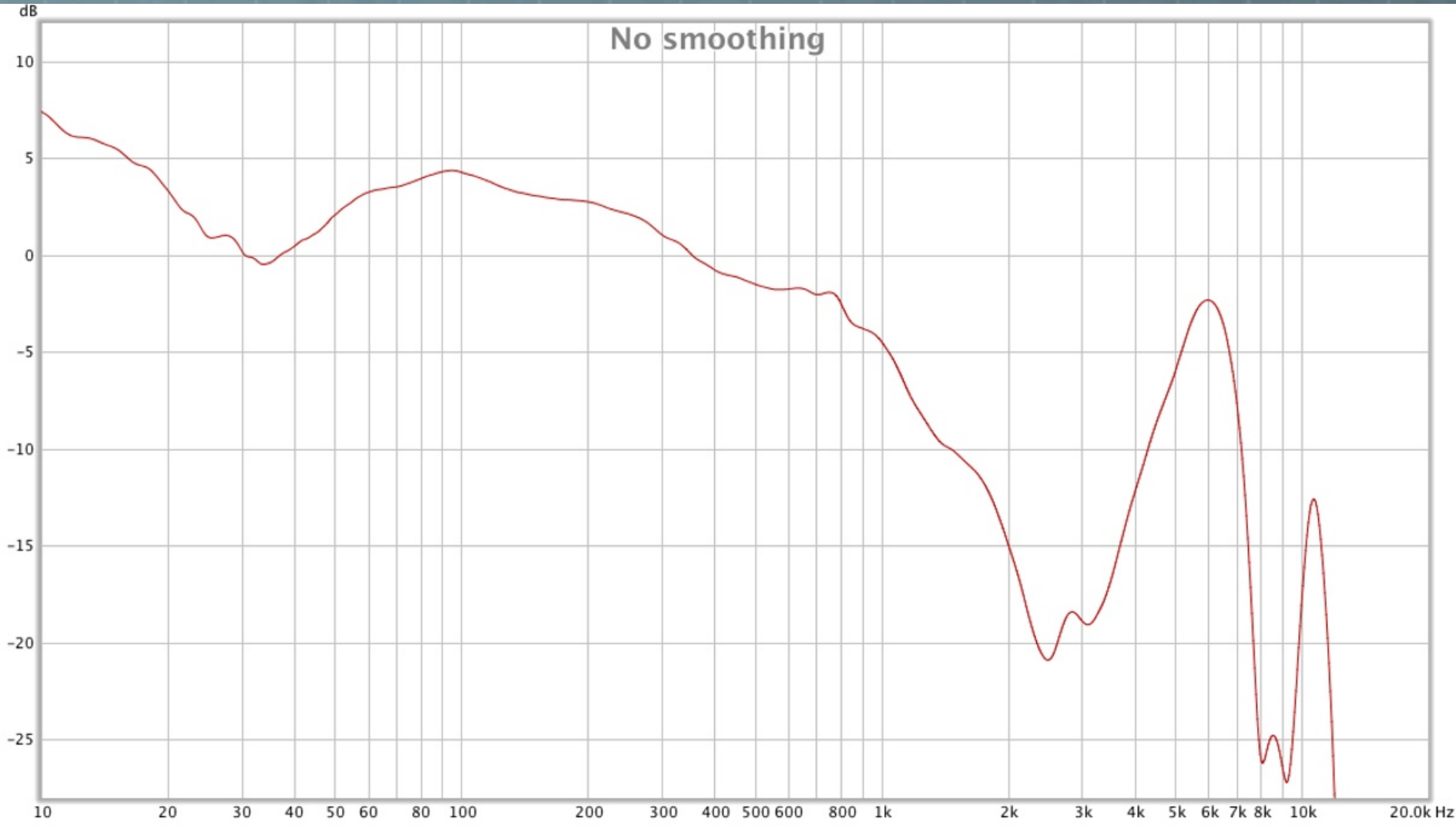
-129.4 dB FS -129.4 dB FS -129.4 dB FS

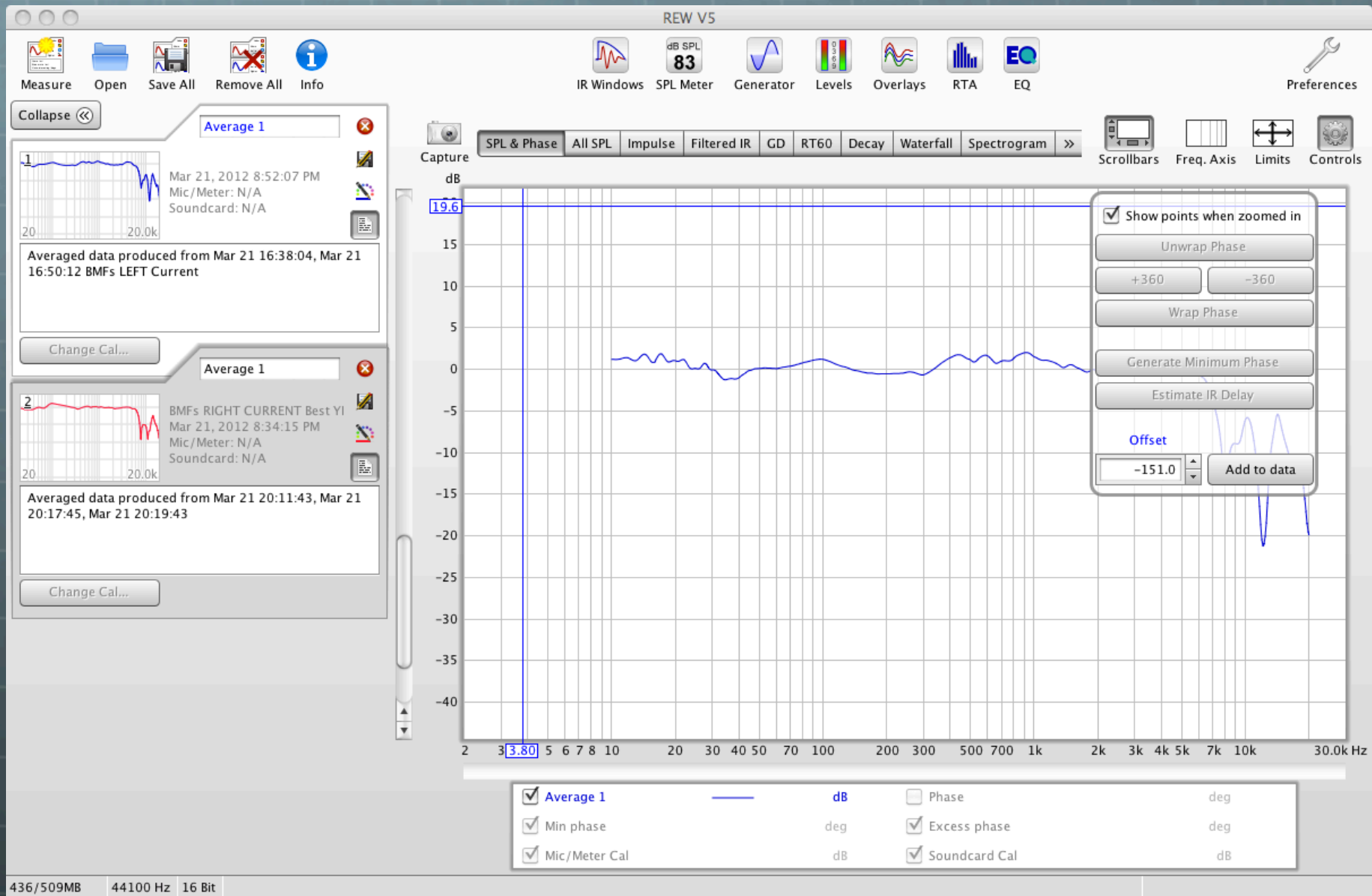
Screenshot from Keith Atkins

Interpreting the Graphs

- 🌐 After measurements have been taking, set up of the limits needs to be done in order interpret the graphs correctly
- 🌐 The y-axis (dB) should be in 5 dB intervals
- 🌐 The x-axis (Hz) should range from 20Hz to 20,000Hz in a logarithmic scale
- 🌐 The offset must be set to general “guess” where 0 dB might be to obtain a good representation of the data



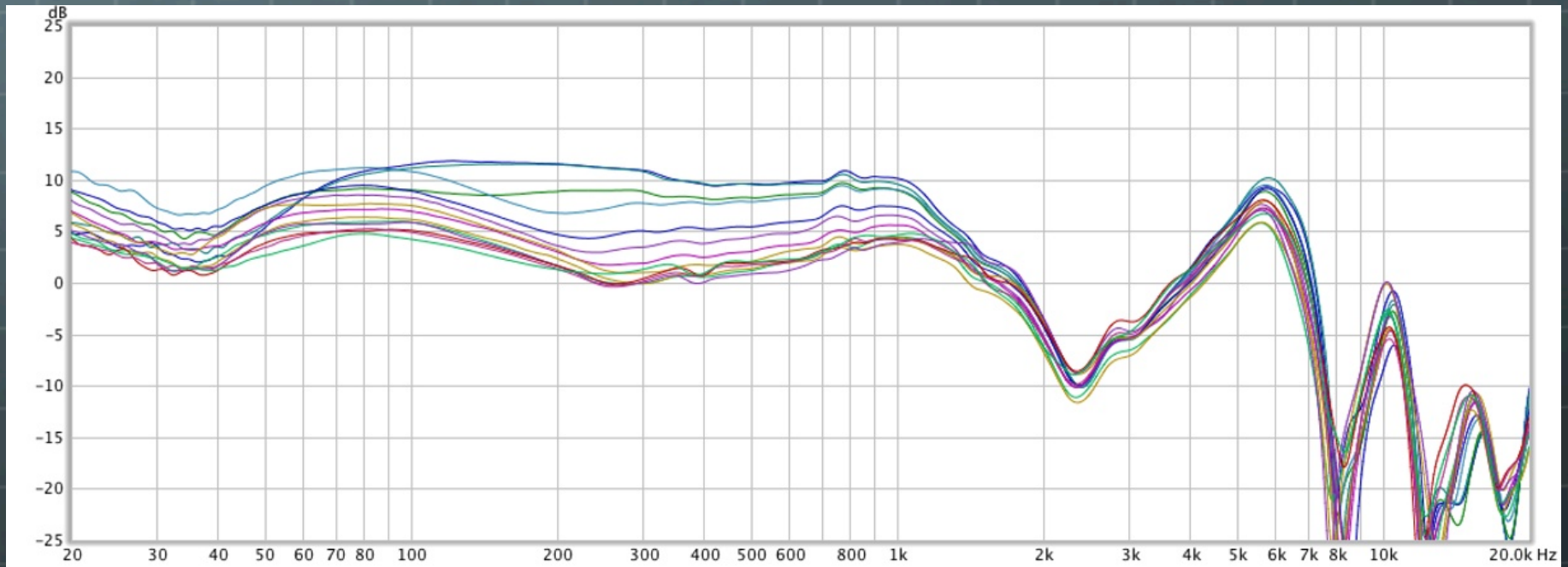




Screenshot from Keith Atkins

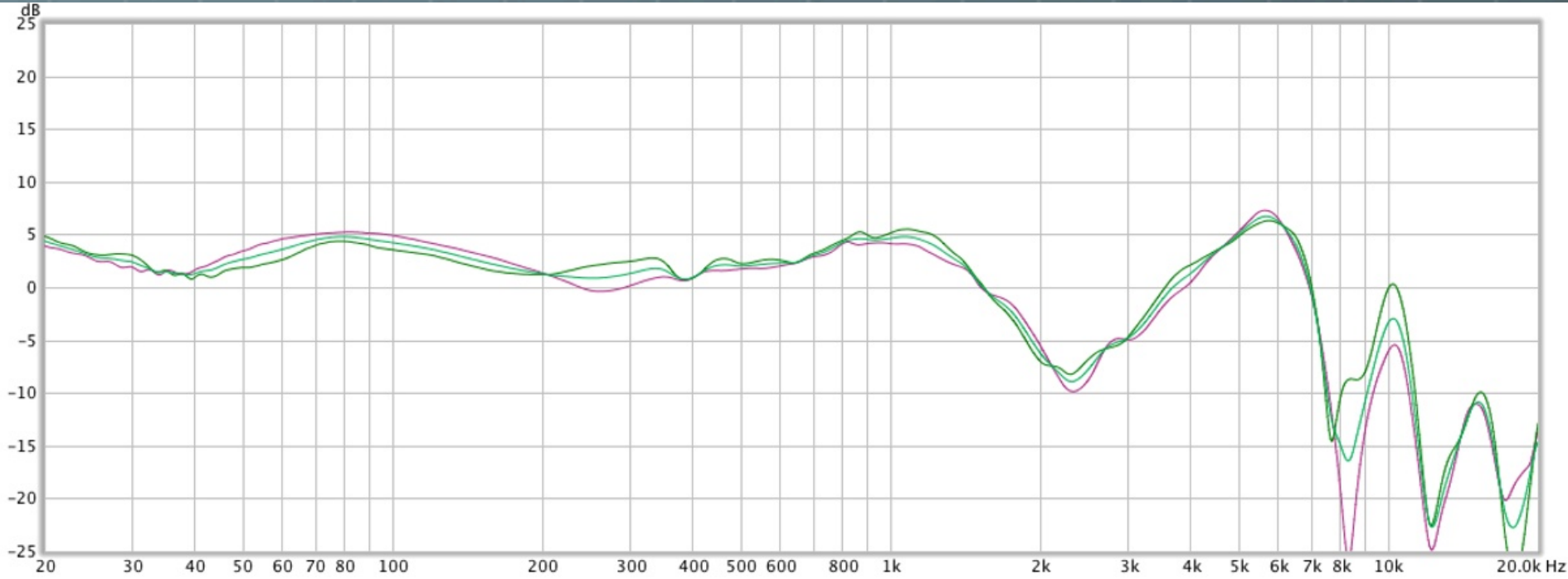
Qualifying Results Graphically

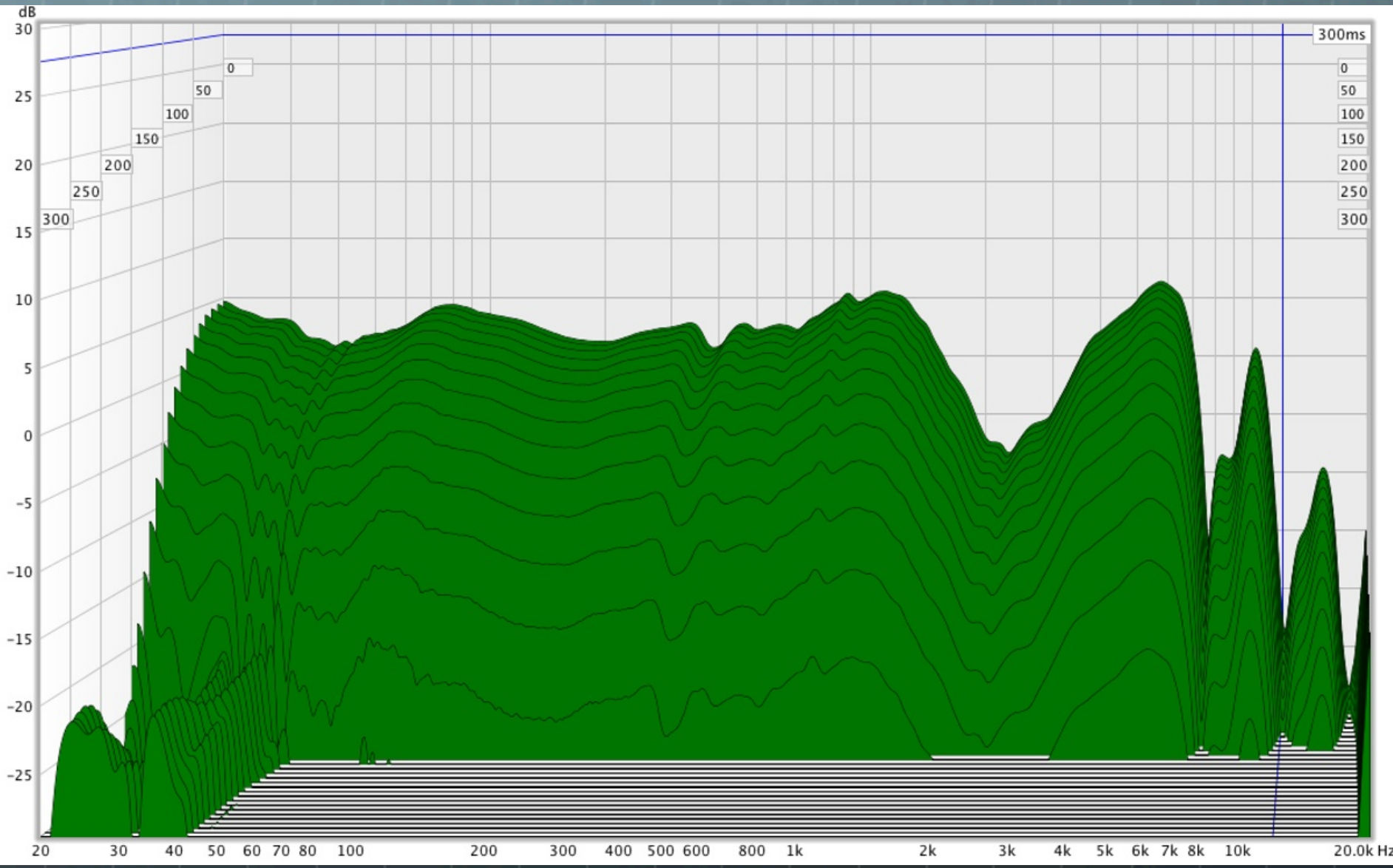
- 🌐 Can see changes in the frequency response due to modifications with consistent measurement techniques

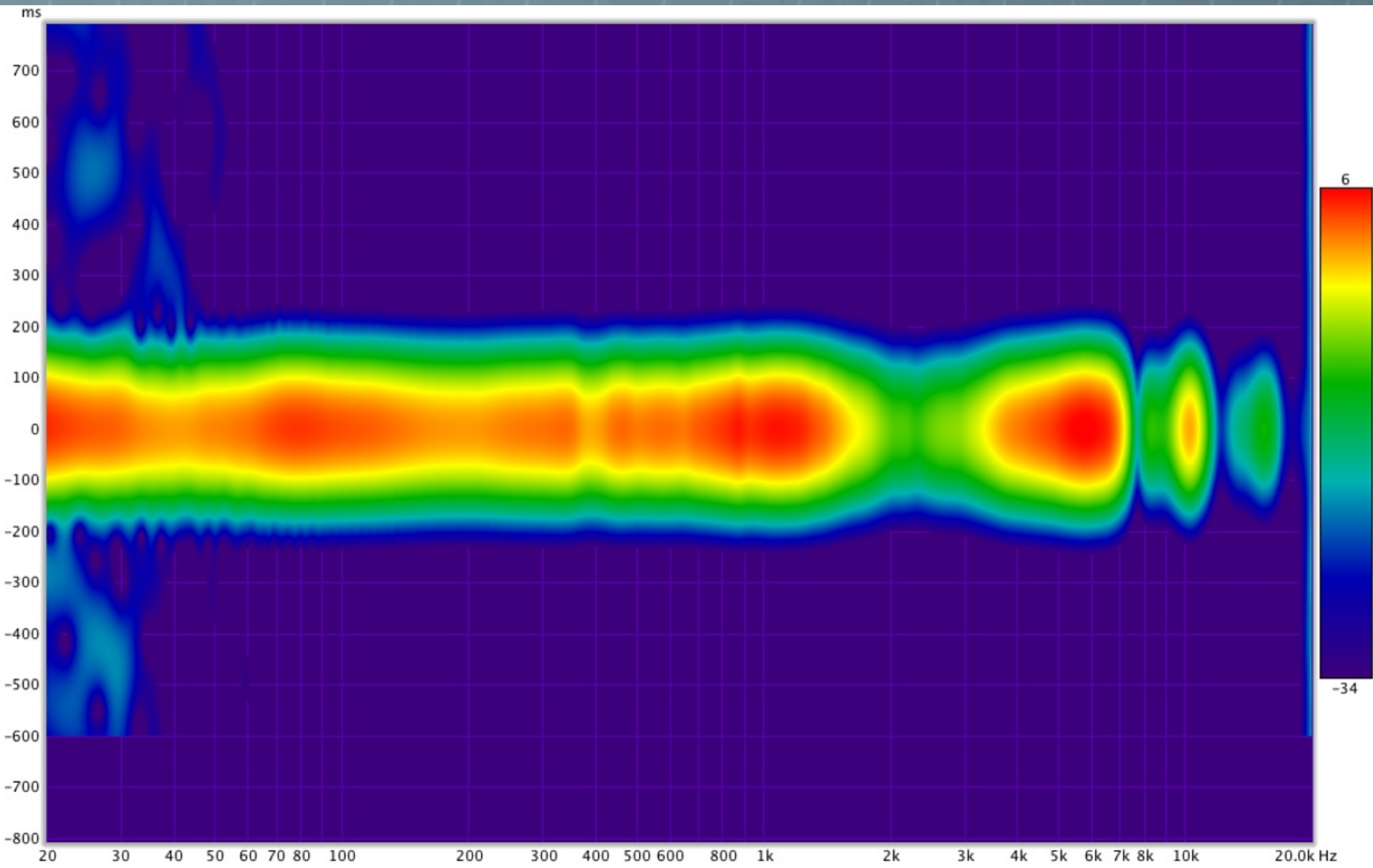


Different Plots

- REW can plot data in many different ways
- Need to choose the type of graph given your specific interest
- Types of graphs available:
 - SPL & Phase
 - All SPL
 - Impulse, Filtered IR, GD, RT60, Decay
 - Waterfall
 - Spectrogram
 - Scope







Future Work

