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Tutorial T3

Percussion Acoustics and Quantitative Drum Tuning

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Summary

Intricate tuning of acoustic drums can have a significant influence on the quality and contextuality of the instrument during a recording session. In this tutorial presentation, waveform and spectral analysis will be used to show that quantitative tuning and acoustic benchmarking is a viable possibility. The principle acoustic properties of popular drums will be shown by live demonstration and aspects relating to drum tuning will be highlighted.

In particular, demonstration and analysis of the following tuning issues will be covered:

- Achieving a uniform pitch across the drum head;
- Tuning drums to a desired musical pitch;
- Manipulating overtones and generating rich timbres;
- Controlling attack and decay profiles;
- Tuning the drum kit as a pitched musical instrument.

Contents

1. A research project to discover the values given to and the techniques involved in drum tuning (Toulson et al, 2008)
   - Music producers
   - Professional musicians
   - Tutors
   - Drum technicians
   - Novice musicians
2. Understanding the acoustic response characteristics of popular drums
3. Developing a quantitative understanding of popular drum tuning
   - Looking at quantitative methods for documented techniques
   - Opportunities for benchmarking and repeatability
   - Tuning to particular musical frequencies
4. Developing a prototype system to aid drum tuning

Drums and percussion in music production

- The importance of a drum sound for the specific music genre
- Drum setup can take 15-25% of the session?
- ‘Right first time’ recording
- Revisiting/replicating drum sounds
- Personal benchmarks
- An indication that studio engineers and producers would embrace technical assistance in drum tuning

The performer's perspective

- Professional musicians
  - Have the ability to tune by ear to a desired sound
  - No guarantee of ability to perform exact repetition
  - Some desire to tune to specific musical frequencies
  - Sometimes disagree with the producer on drum setups
- Novice musicians
  - Drum tuning is a considerable challenge
  - No quantified education methods
  - Would embrace the ability to tune their kit to a particular genre or to replicate the sound of a favourite musician
  - Often uncomfortable with advanced technology and engineering terminology

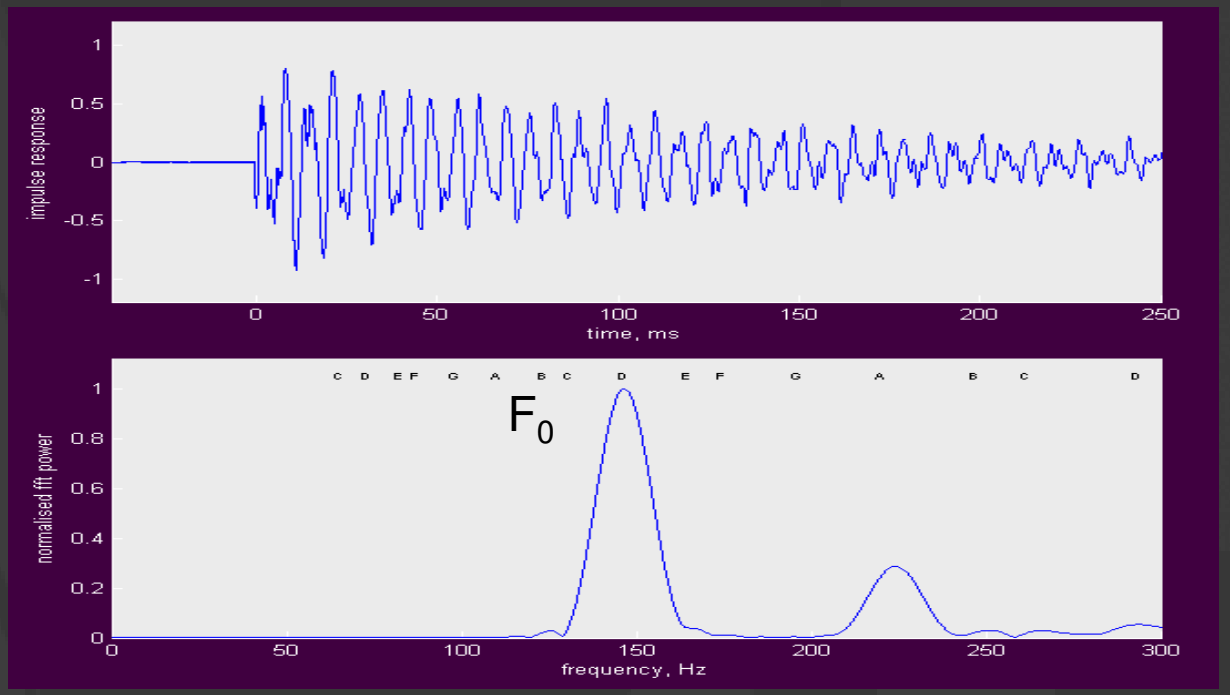
Understanding the acoustic response characteristics of popular drums

- Percussion acoustics researched by Thomas Rossing (2000), who states:

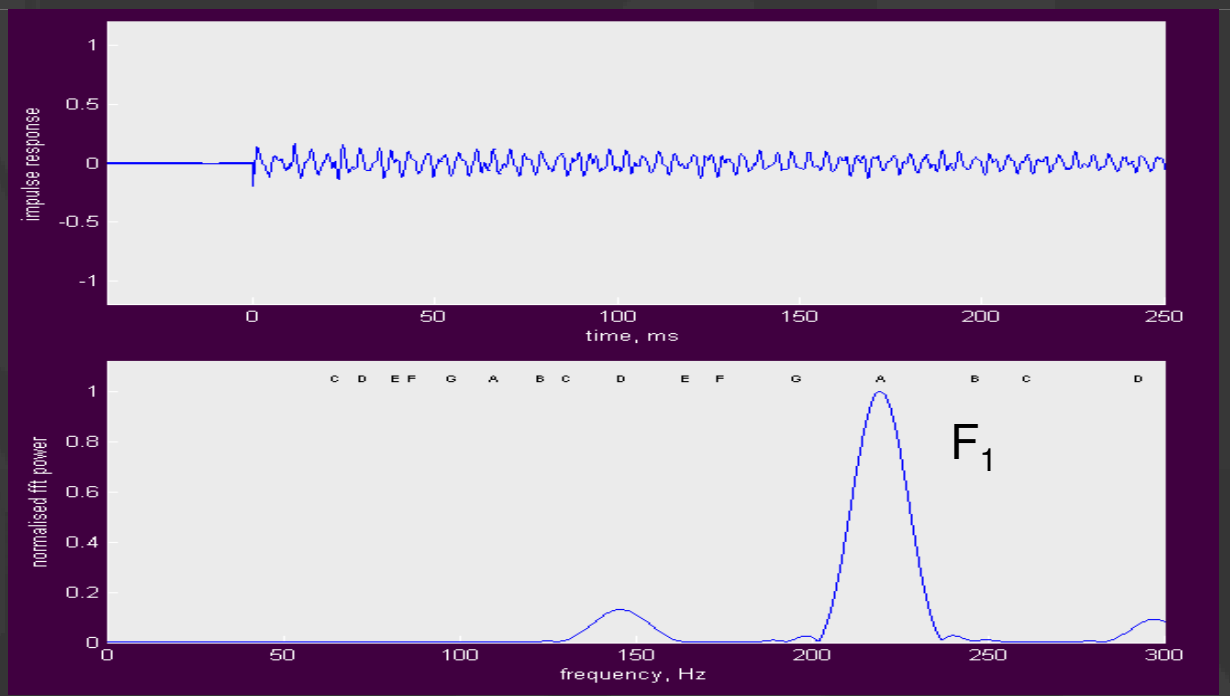
"relatively little has been written about scientific research on these instruments"

- A complex multi-degree-of-freedom instrument
  - Multiple vibrating masses; drum heads, drum shell, air
  - 12-20 tuning lugs per drum
  - Complex boundary conditions (taught drum heads)
- Very difficult to model accurately mathematically
- Some simple observations of drum acoustics that can be useful when considering drum tuning (as described by Toulson and Richardson, 2009)

Centre impact and response



Edge impact and response



Understanding the acoustic response characteristics of popular drums

- F0 is owing to the mass of air vibrating inside the drum. This frequency therefore depends on:
  - the dimensions of the drum (diameter and depth)
  - the mechanical boundary conditions of the two drum heads (tension, weight, elasticity etc
  - This can be demonstrated by the fact that F0, when excited on either the batter or resonant head, is always the same
- F1 is a localised vibration mode attributed to the individual drum heads. This frequency is therefore dependent on:
  - the mechanical properties of the drum head being struck
  - the tension of the drum head being struck
  - the elastic properties of the air in contact with the drum head
  - This can be demonstrated by the fact that F1(batter) is different to F1(resonant).
- Conditions for F0 and F1 are only subtly different, but different enough to allow F0 and F1 to be tuned independent of each other.
- Higher frequency modes are either overtones of F0 and F1, or higher order modes relating to the shell and hardware properties.

Introducing drum tuning

- What is drum tuning? What is the correct method?
  - See publications by Ranscombe (2006a, 2006b) and Schrodel (2002) for popular (qualitative) examples of best practice.
- Being in control of the drum sound.
- The difference between tuning and timbre?
  - Dimensions
  - Drum heads
  - Shell material
  - Snare wires
  - Sticks
  - Gesture
  - Microphone position
- Drums as musical instrument? Pitched or unpitched?

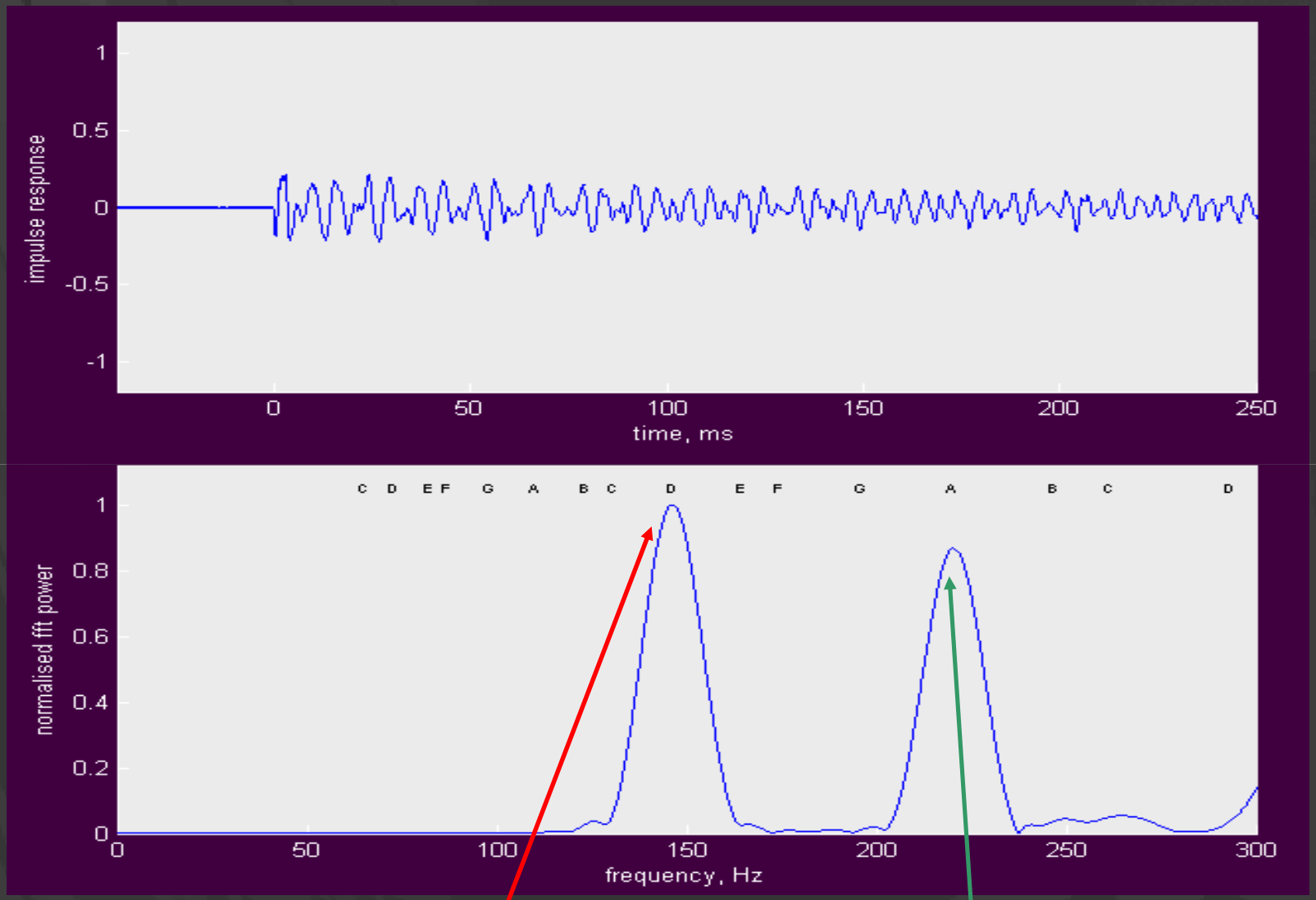
Some quotes on drum tuning and drum production

- In comparison to other instruments, drums are described as being “much more difficult and challenging” to tune (Schroedl, 2002)
- A uniform or even pitch around the perimeter drum is desired for a “nice tone that decays with a smooth even note” (Ranscombe, 2006b)
- “The two things that identify a record are the vocal and the snare drum” (John Leckie in Massey, 2003)
- “It’s a small thing like tuning your snare drum to the track, if someone is singing in A and your snare is B flat your jiving all over the place it just doesn't sound right.” (Geoff Dougmore interviewed by Dolbear, 2009)
- ‘If your drums are well tuned and with the correct head choices, there really should be no need for additional dampening ... no o-rings and absolutely no pillows, towels or other such stuff. ’ (Ranscombe, 2006b)
- “I always tell the producer or artist or whoever’s booking me to book a day a song…If there’s a lot of repair work to be done – if, for example, I have to go back in and replace drums with samples and make up triggers for gates so that you can get past the leakage – then it will take longer. To me that’s the stuff that really should have been done beforehand, or it should have just been recorded better.” (Chuck Ainsley in Massey, 2003)

Quantitative drum tuning methods

- Setting the fundamental drum pitch and overtones. Tuning the drum heads relevant to each other.
- Achieving a uniform pitch around the drumhead
- Tuning the pitch of the drums in a drum set
- Controlling attack and decay profiles

Setting the fundamental drum pitch and overtones

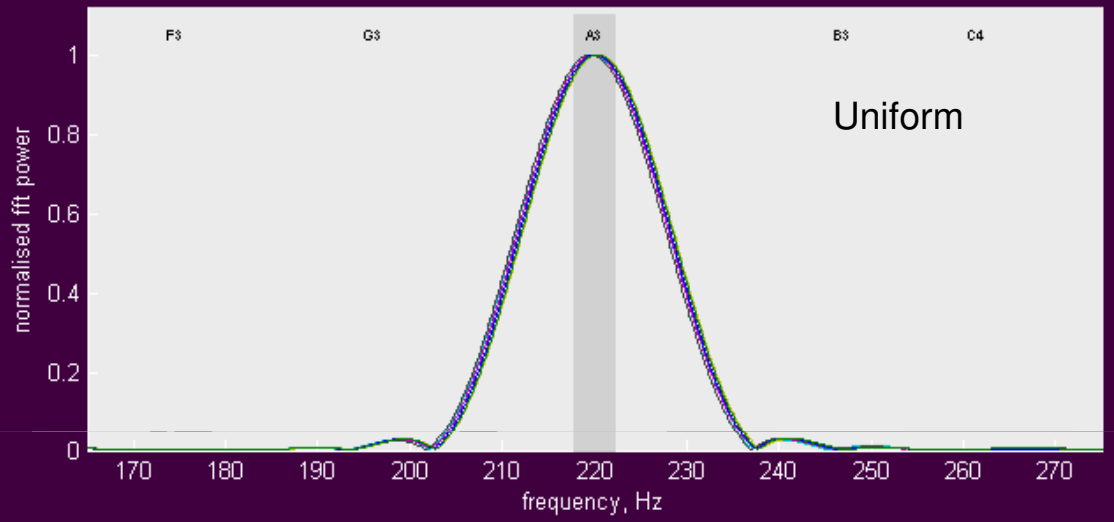


$F_0 = D_3 = 146.8$ Hz

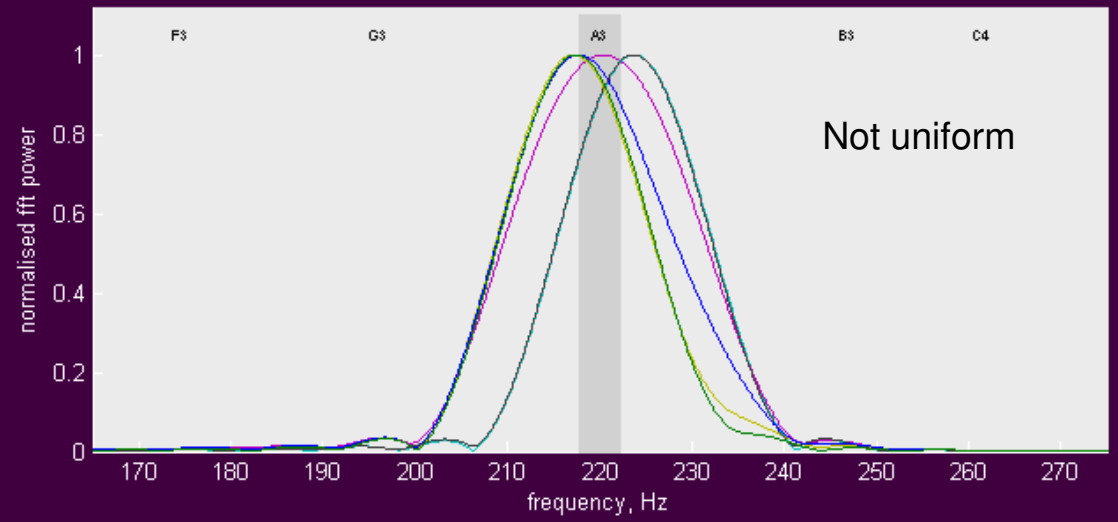
$F_1 = A_3 = 220$ Hz

Achieving a uniform pitch around the drumhead

		F_1(Hz)	dF_1(Hz)
<>	Lug 1	219.6	-0.4
<>	Lug 2	219.9	-0.1
<>	Lug 3	220.4	+0.4
<>	Lug 4	219.6	-0.4
<>	Lug 5	220.1	+0.1
<>	Lug 6	220.3	+0.3

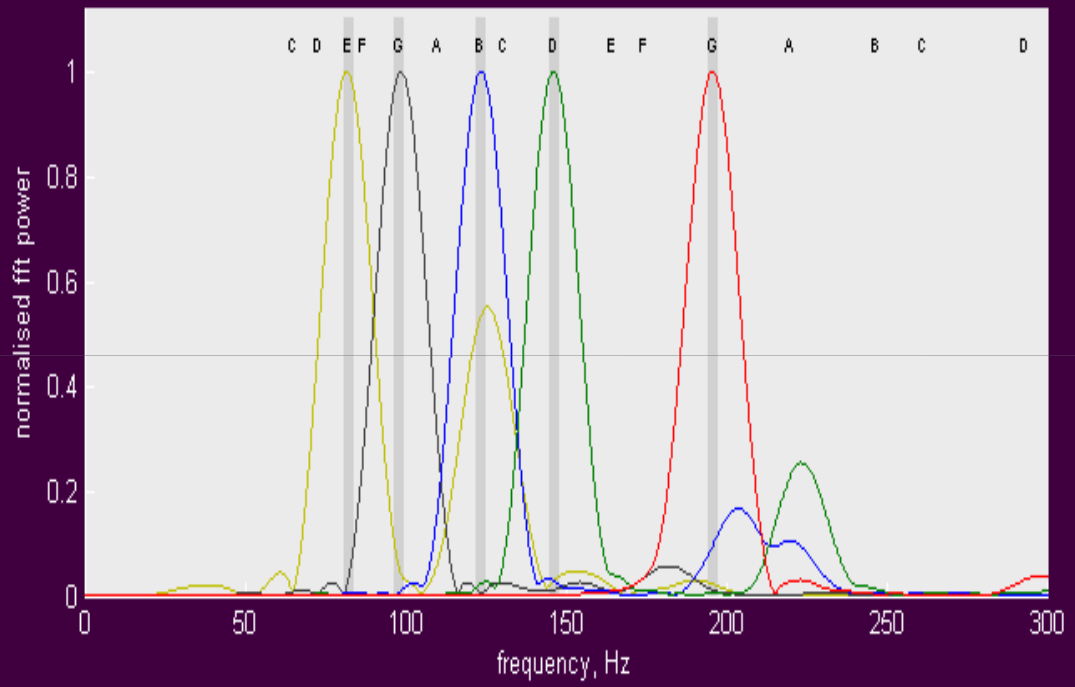


		F_1(Hz)	dF_1(Hz)
V	Lug 1	223.7	+3.7
<>	Lug 2	220.5	+0.5
^	Lug 3	217.2	-2.8
V	Lug 4	223.7	+3.7
<>	Lug 5	217.8	-2.2
^	Lug 6	217.4	-2.6



Tuning the pitch of the drums in a drum set

	Target (Hz)	F_0 (Hz)	dF_0 (Hz)
20" Kick Drum	82.4	81.8	-0.6
16" Floor Tom	98	98.7	+0.7
13" Rack Tom	123.5	123.6	+0.1
12" Rack Tom	146.8	146.1	-0.7
14" Snare	196	195.8	-0.2



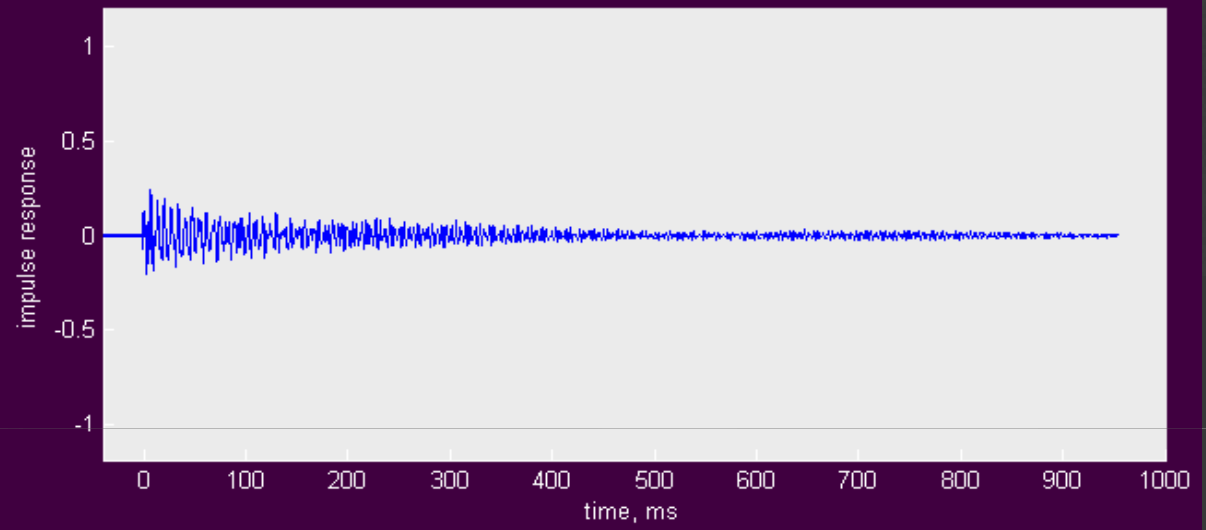
snare → 12” tom → 13” tom → 16” floor tom → 20“ kick drum

=

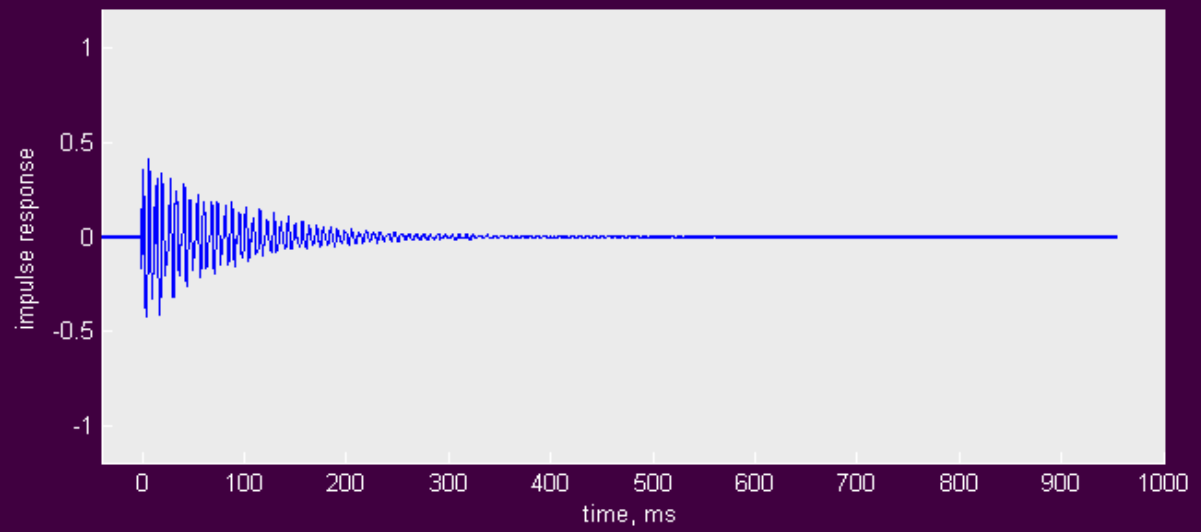
G3 → D3 → B2 → G2 → E2

Analysing the decay profile of a drum setup

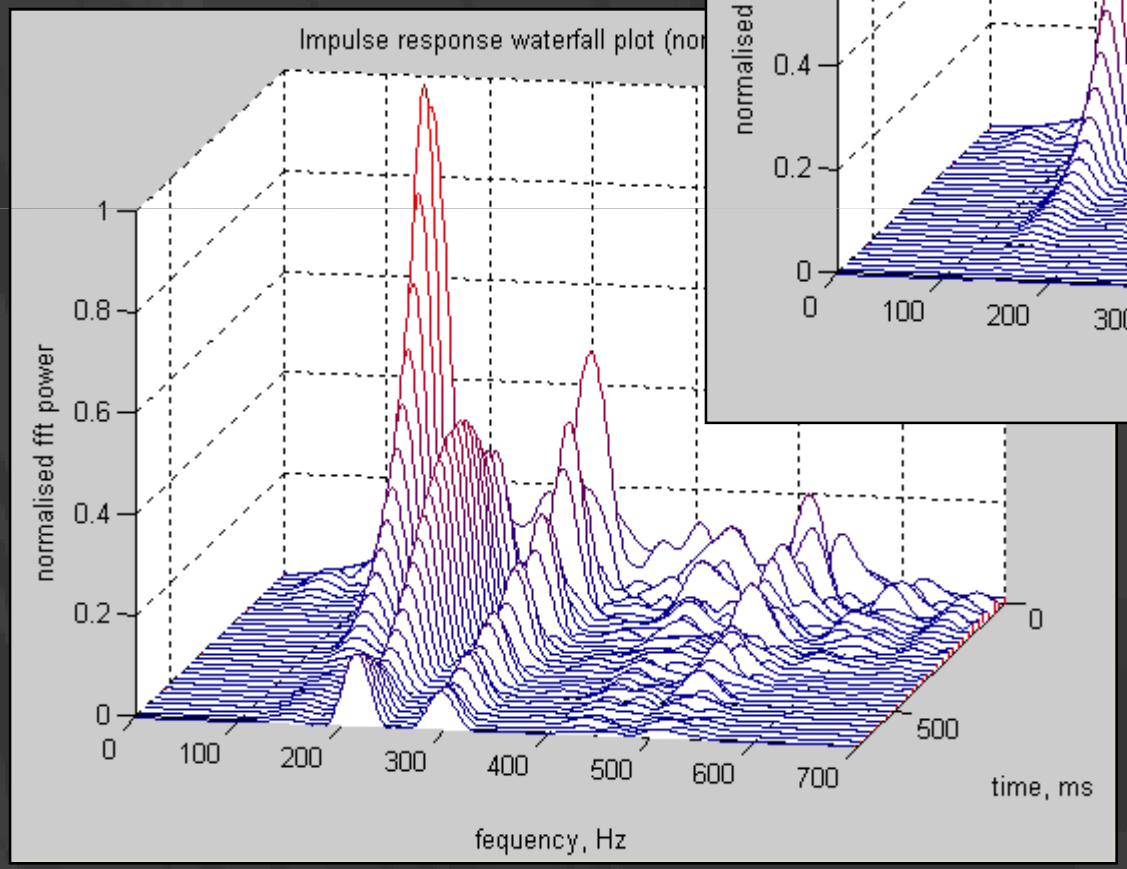
Attack time, Ta	8.7	ms
Decay time, Td	752	ms

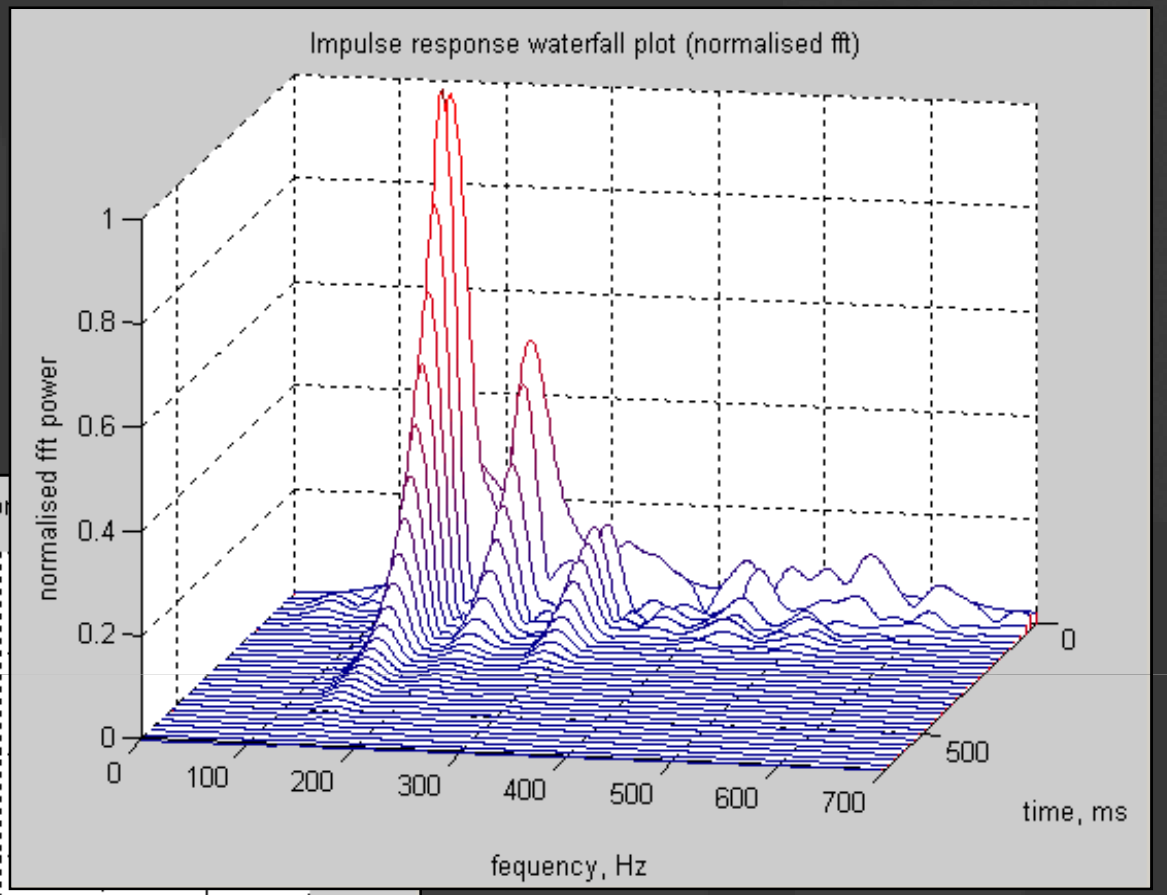


Attack time, Ta	5.5	ms
Decay time, Td	199	ms



Analysing the decay profile of a drum setup





Tuning for different music genres

- In general, drums for Jazz:
  - tuned relatively high
  - using smaller drum shells
  - with long decay times
- Drums for Rock music are often:
  - tuned low (except the snare?)
  - with larger drum shells
  - heavily damped
- Research of drum tuning setups for different music genres is in progress.
- Microphone techniques for specific genres have an influence here. For example, close mic-ed drums pick up longer decay envelopes.
- An example to show the tuning range of a particular drum kit:

5 piece birch drum kit consisting of :

14” snare

12” tom

13” tom

16”tom

20” kick

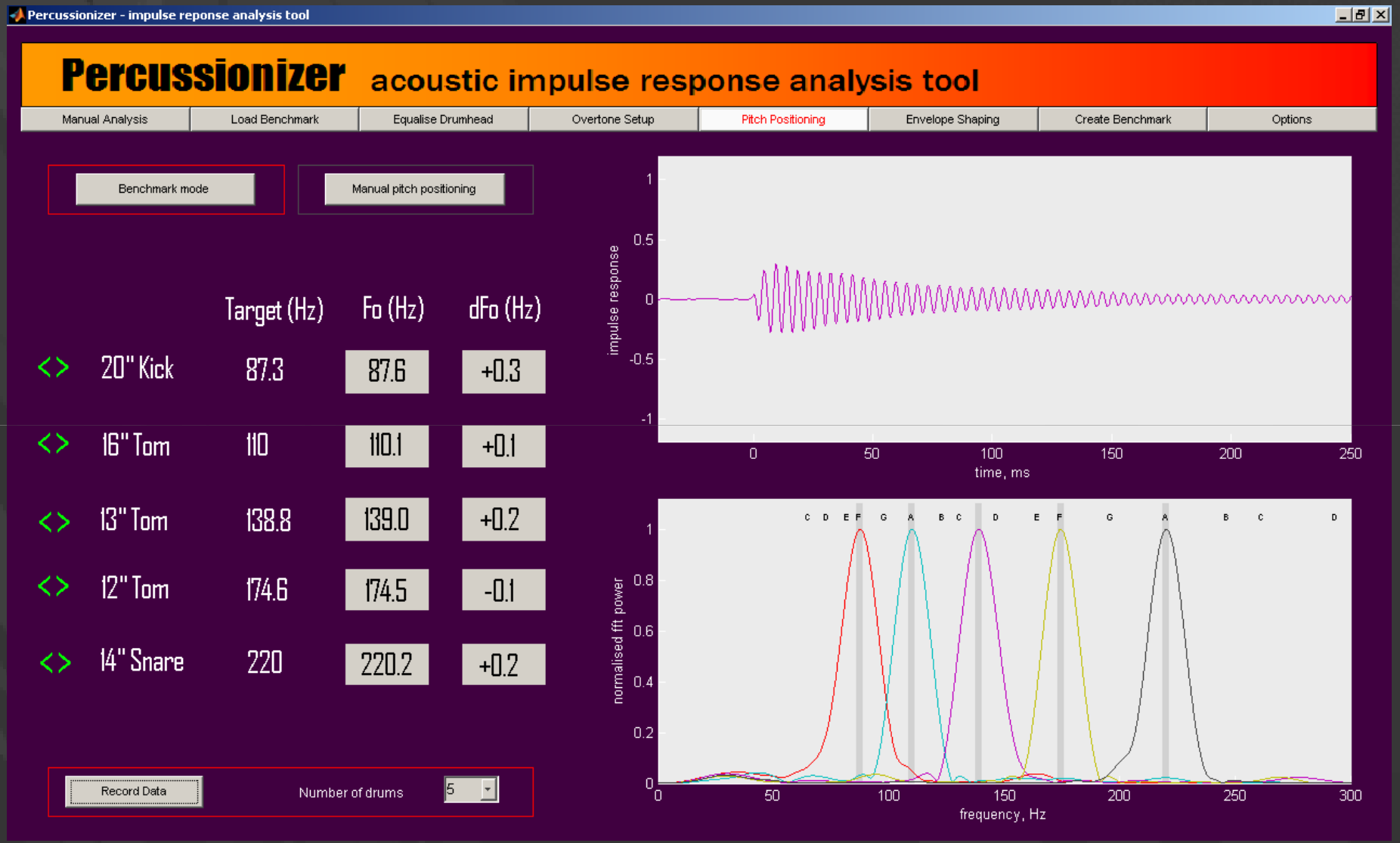
Drum heads:

- Evans EC2 Coated (toms)
- Remo Pinstripe (snare and kick)
- Standard resonant heads throughout

Microphones used:

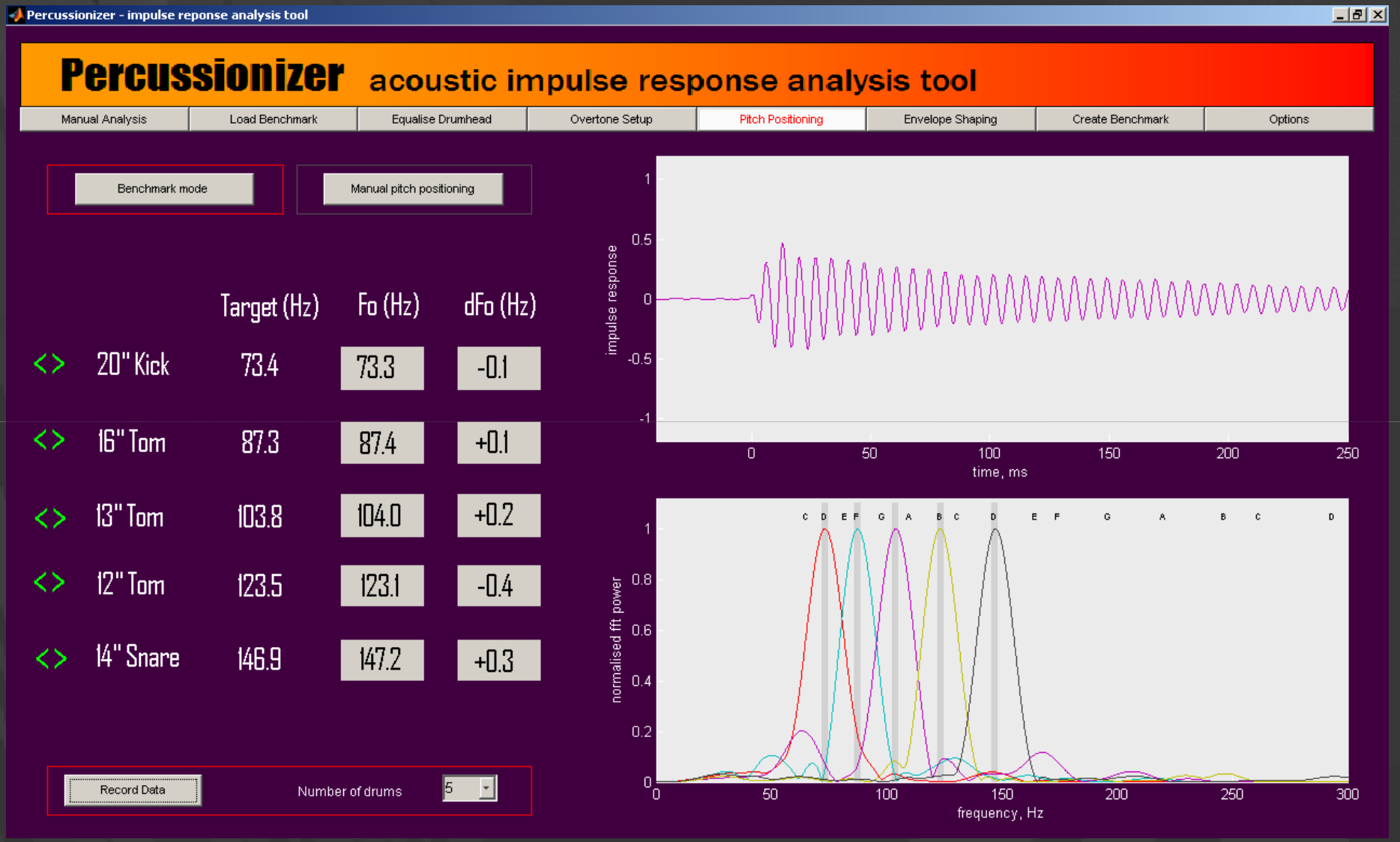
- Shure Beta 57 (toms and snare)
- Sennheiser MD421 (kick)
- AKG C414 (overheads)

Tuning setup 1 – High Tuning (Jazz)

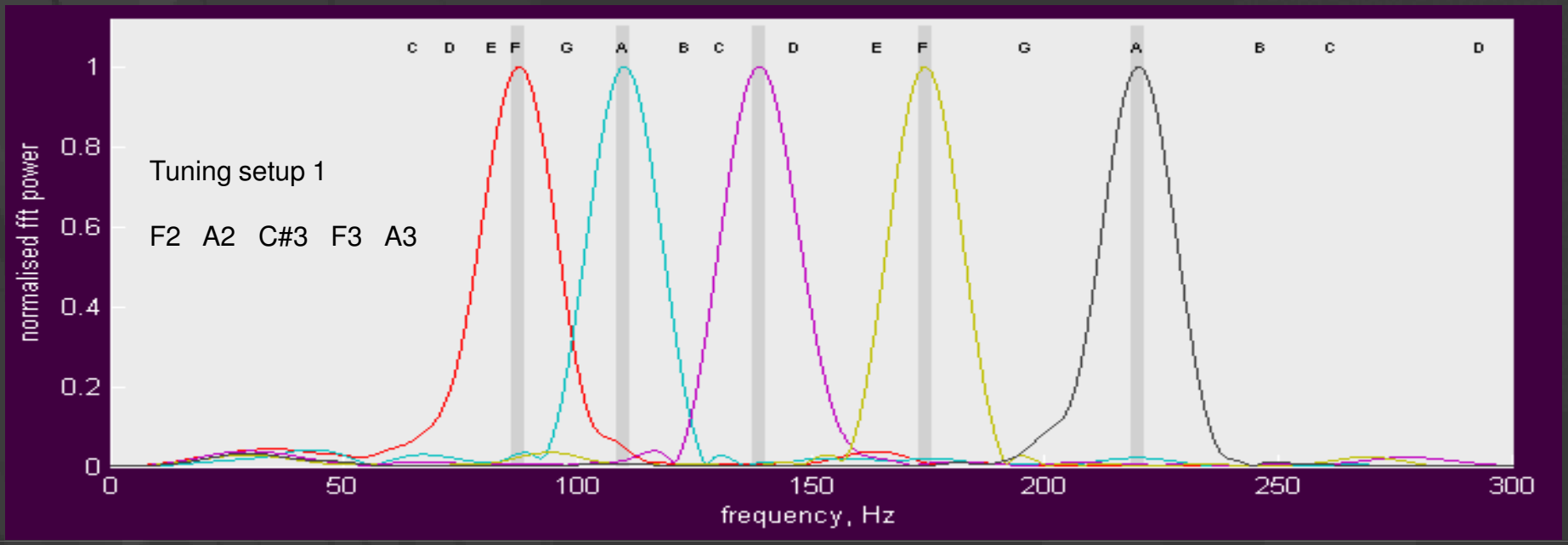


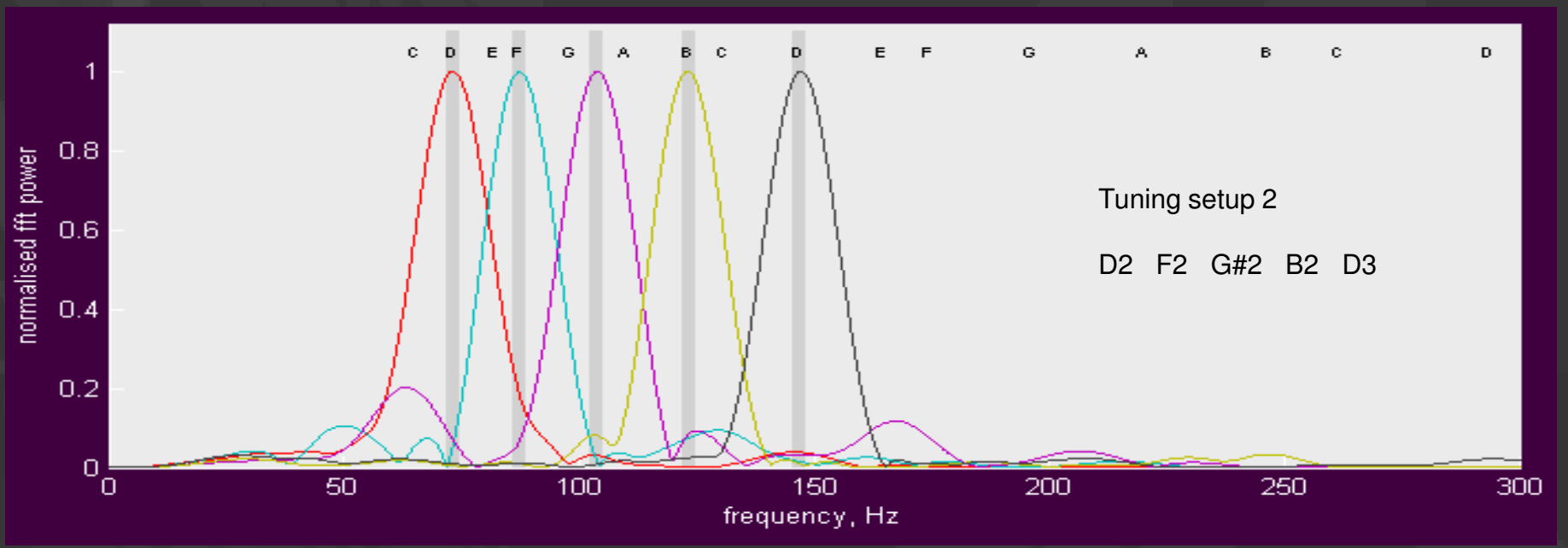
Tuning setup low → high: F2 A2 C#3 F3 A3

Tuning setup 2 – Low Tuning (Rock)

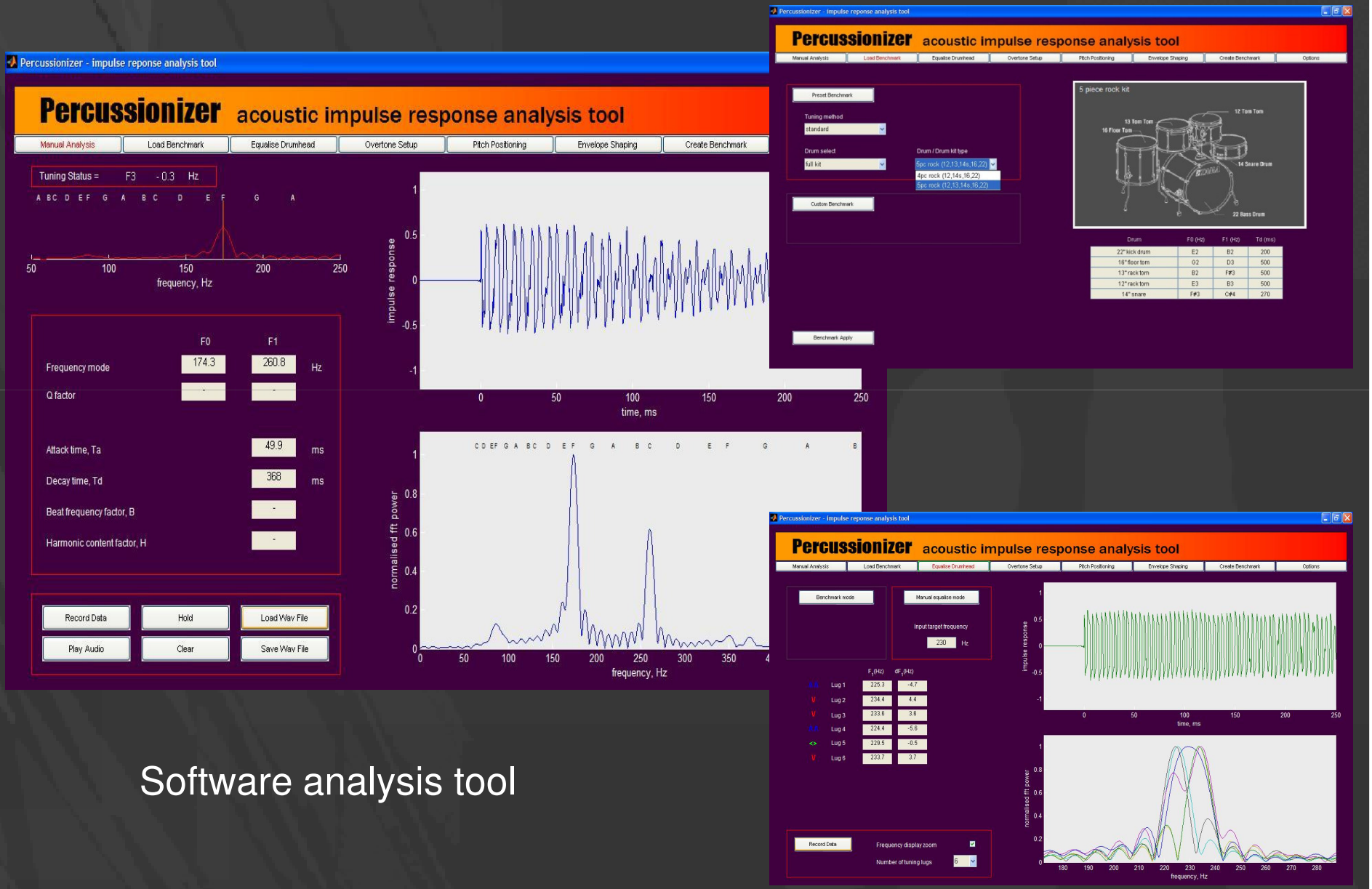


Tuning setup low → high: D2 F2 G#2 B2 D3


C D E F G A B C D E F G A B C D
normalised fft power
0
0.2
0.4
0.6
0.8
1
0
50
100
150
200
250
300
frequency, Hz
Tuning setup 1
F2 A2 C#3 F3 A3

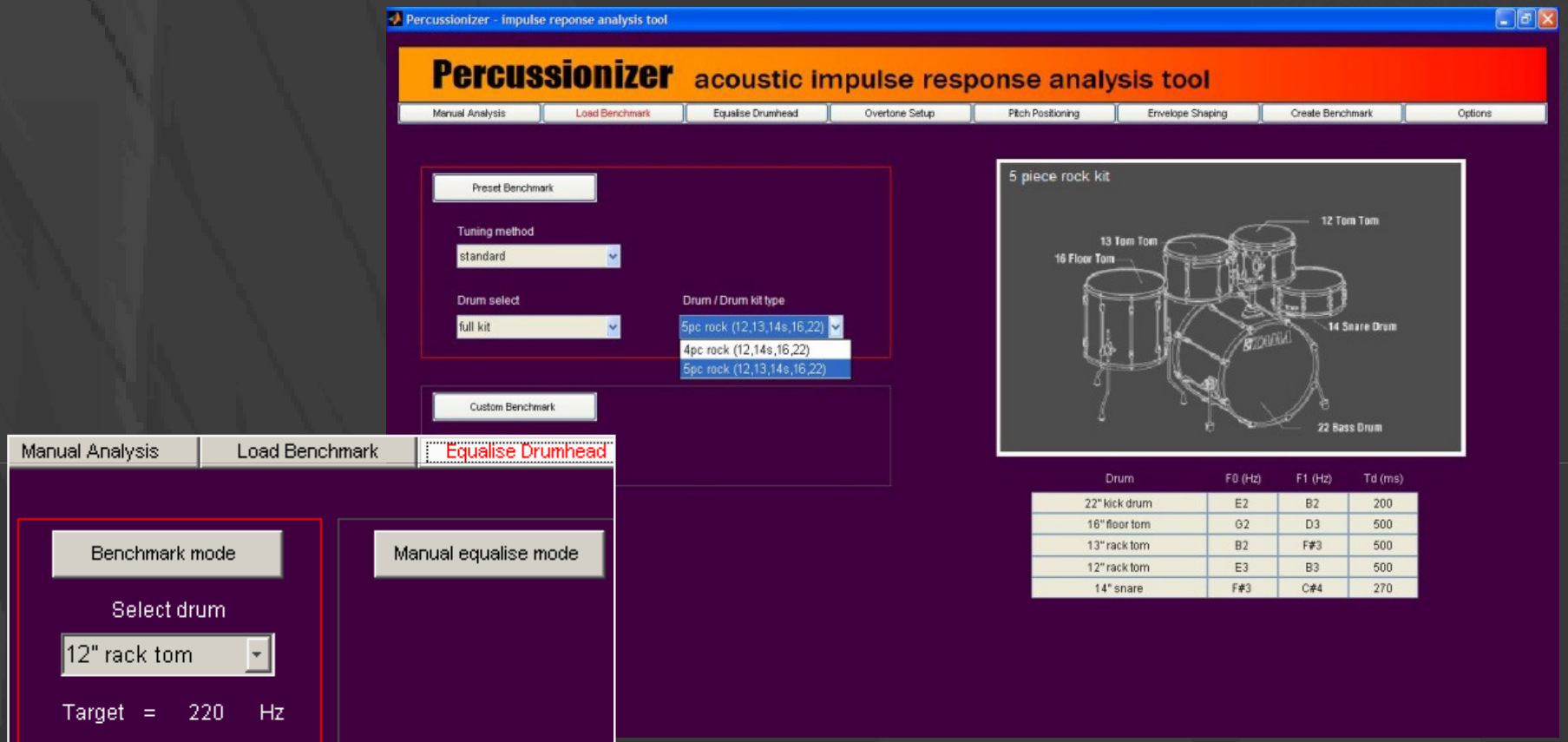

C D E F G A B C D E F G A B C D
normalised fft power
0
0.2
0.4
0.6
0.8
1
0
50
100
150
200
250
300
frequency, Hz
Tuning setup 2
D2 F2 G#2 B2 D3

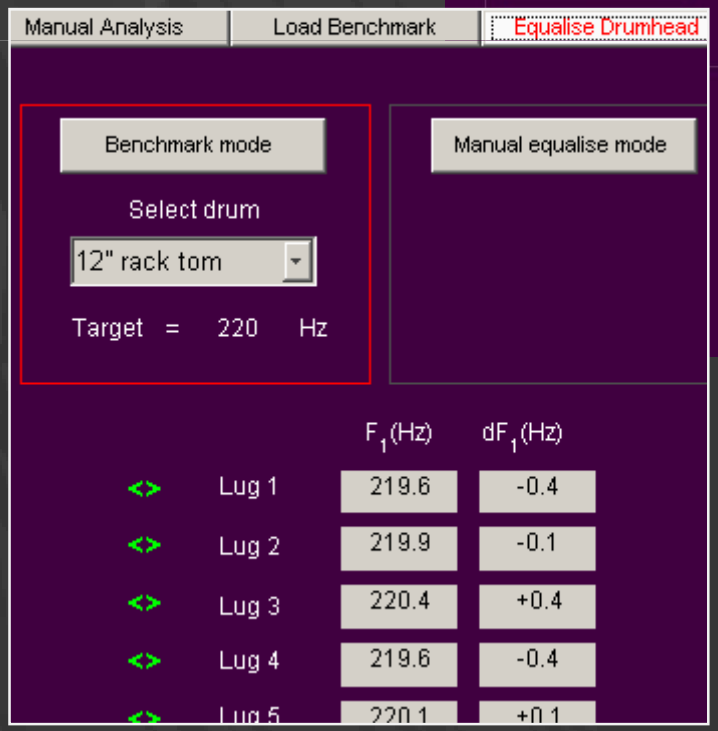
Development of a hardware/software system to aid drum tuning



Software analysis tool

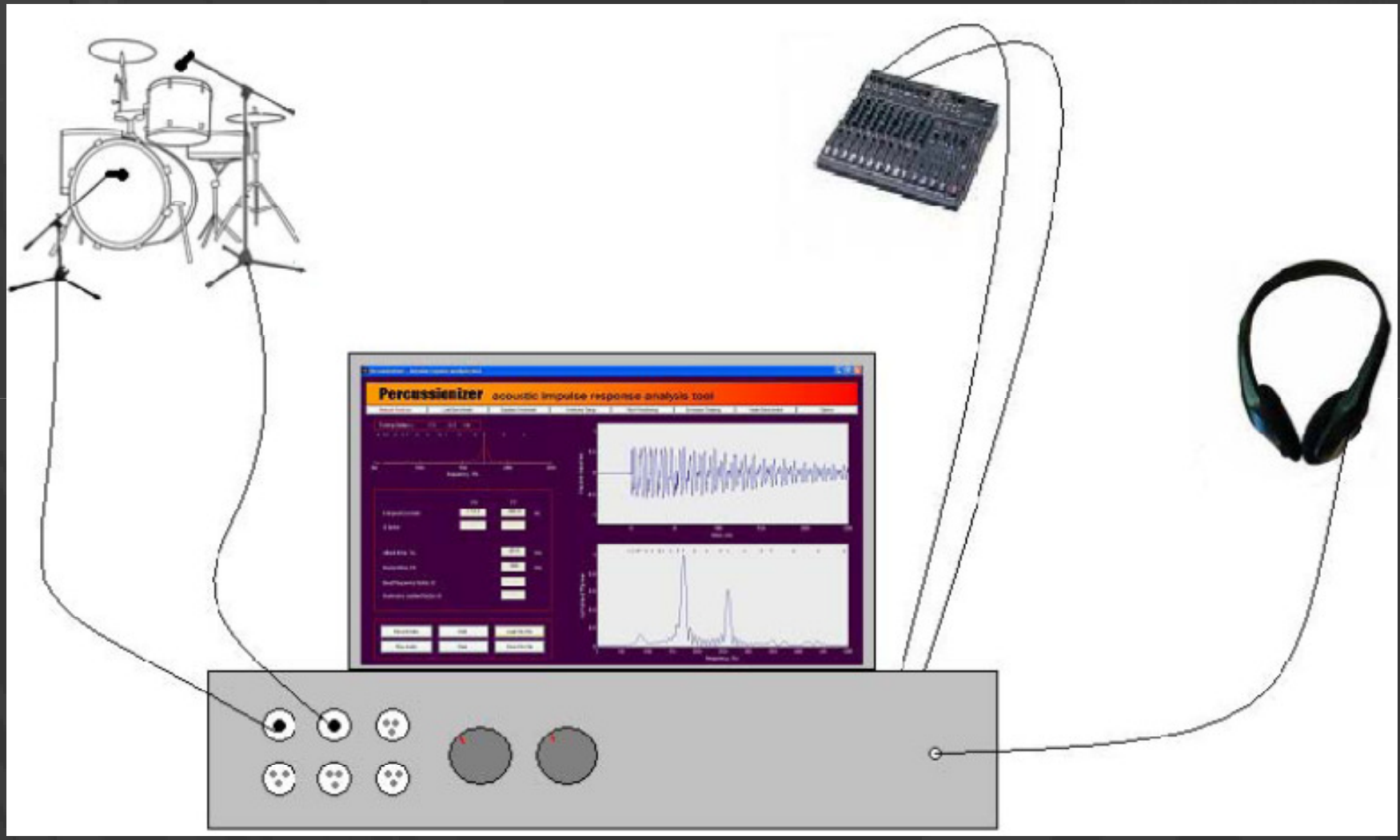
Development of a hardware/software system to aid drum tuning





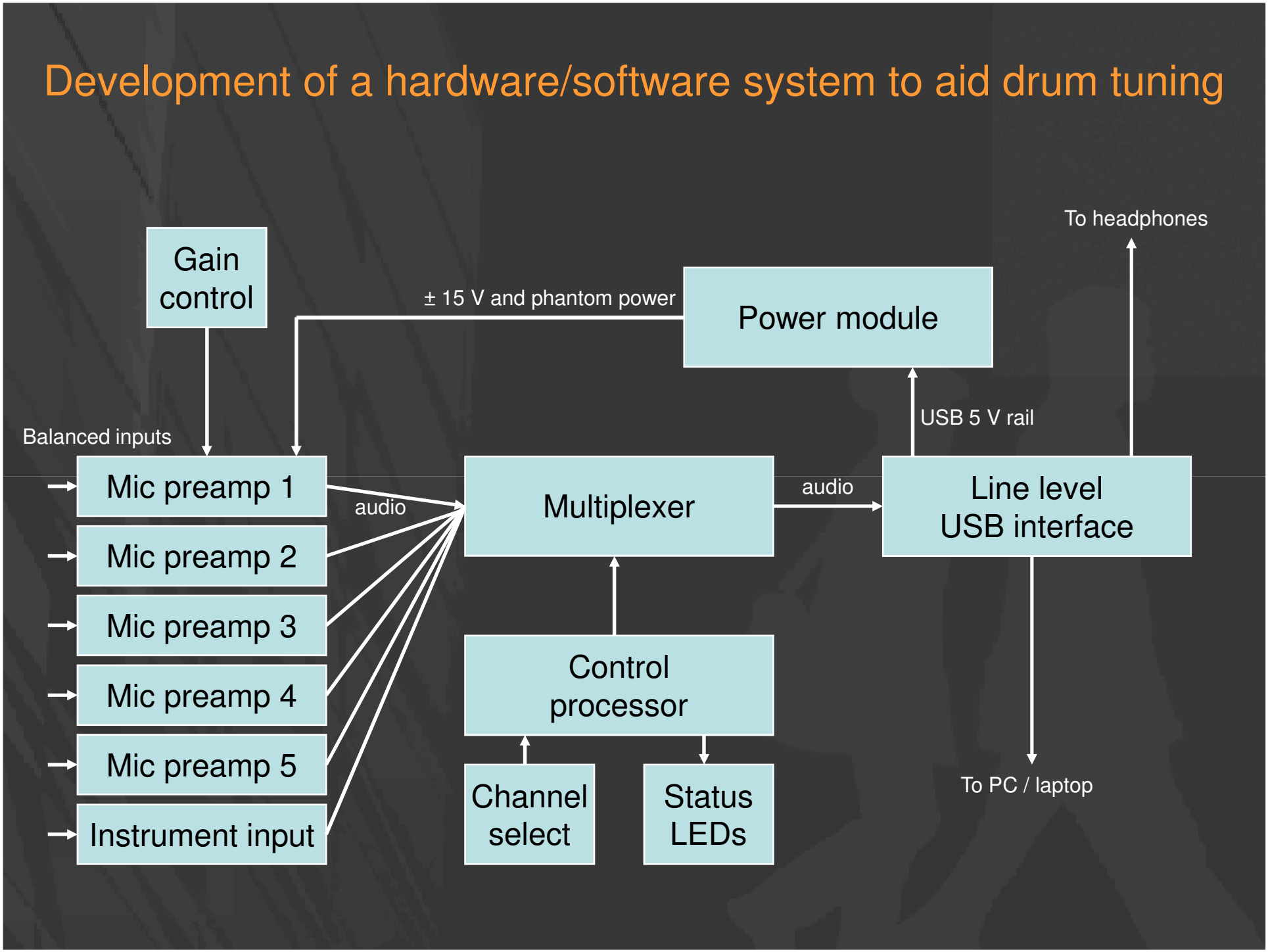
Benchmarking and repeatability

Development of a hardware/software system to aid drum tuning



Rack mount studio hardware system to assist drum tuning (prototype)

Development of a hardware/software system to aid drum tuning



Development of a hardware/software system to aid drum tuning

Development of a hardware/software system to aid drum tuning

Future research and development

- Further investigation of quantitative drum tuning for specific music genres
- Continued investigation of the value of the gained knowledge to the musician and record production community
- Investigate other drum tuning/timbre factors
  - Drum head types
  - Drum shell material and construction
  - Drum dimensions
  - Orchestral drums
- Commercialisation of tools

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Summary / Recap

1. Described a research project to discover the values given to and the techniques involved in drum tuning
2. Discussed the acoustic response characteristics of popular drums
3. Demonstrated an assisted method for popular drum tuning
   - Quantitative methods for documented techniques
   - Benchmarking and repeatability
   - Tuning to particular musical frequencies
4. Described a prototype system to aid drum tuning
5. Discussion of future research objectives
6. Question and answer


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