



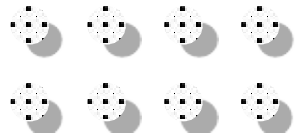
# **An Introduction to Chord Recognition**

## Through FFT

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28<sup>th</sup> March, 2023

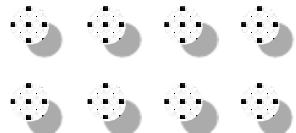
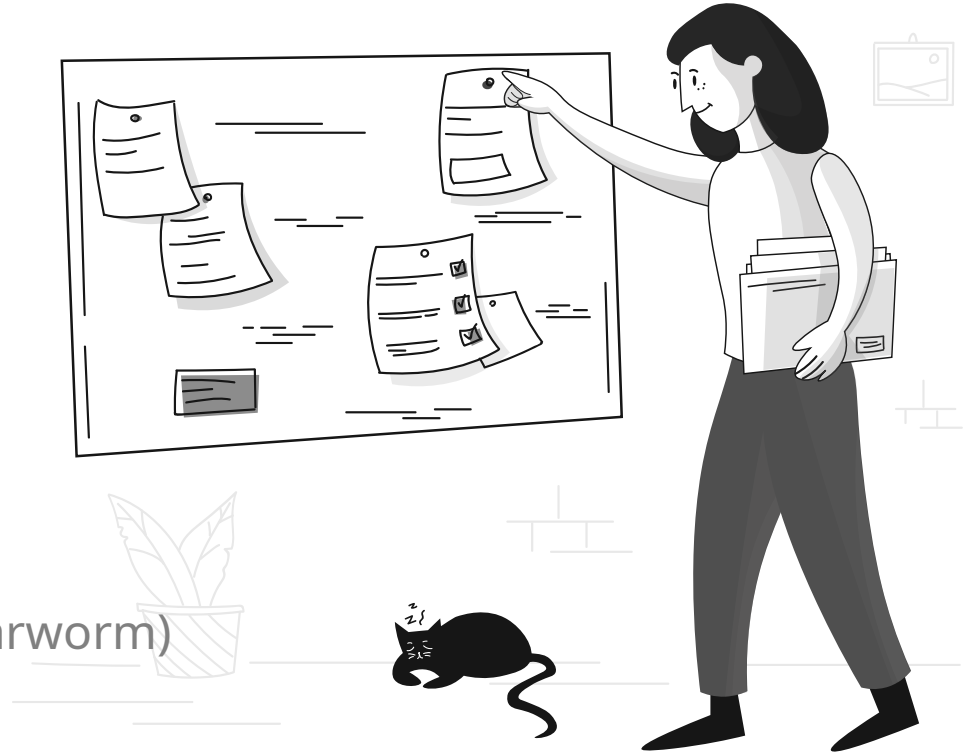
# Background info about the project:

- Music Information Retrieval (MIR)
- OMR
- QbH
- **Other adaptive models**
  - Style/Genre Classification
  - Emotion/**Chord Recognition**
- Practical, Code-heavy
- Non-technical, Simplistic



# Motivations for Chord Recognition:

- Musicology
  - Harmonic Analysis
  - Understanding of Music
- Medical treatment
  - Involuntary Musical Imagery (SSS / Earworm)
- Identification of Music



## Chords

Musical constructs that typically consist of **three** or more **notes**

## Scientific Pitch Notation

Pitch Class (Chroma) and Octave Number  
together form note names  
eg. A4, C4

## 12-TET

Twelve-tone equal-tempered scale

$$F_{\text{pitch}}(p) = 2^{(p-69)/12} \cdot \underline{440}$$

$$F_{\text{pitch}}(p+1)/F_{\text{pitch}}(p) = 2^{1/12} \approx 1.059463$$

$$p \in [0 : 127]$$



## Partial

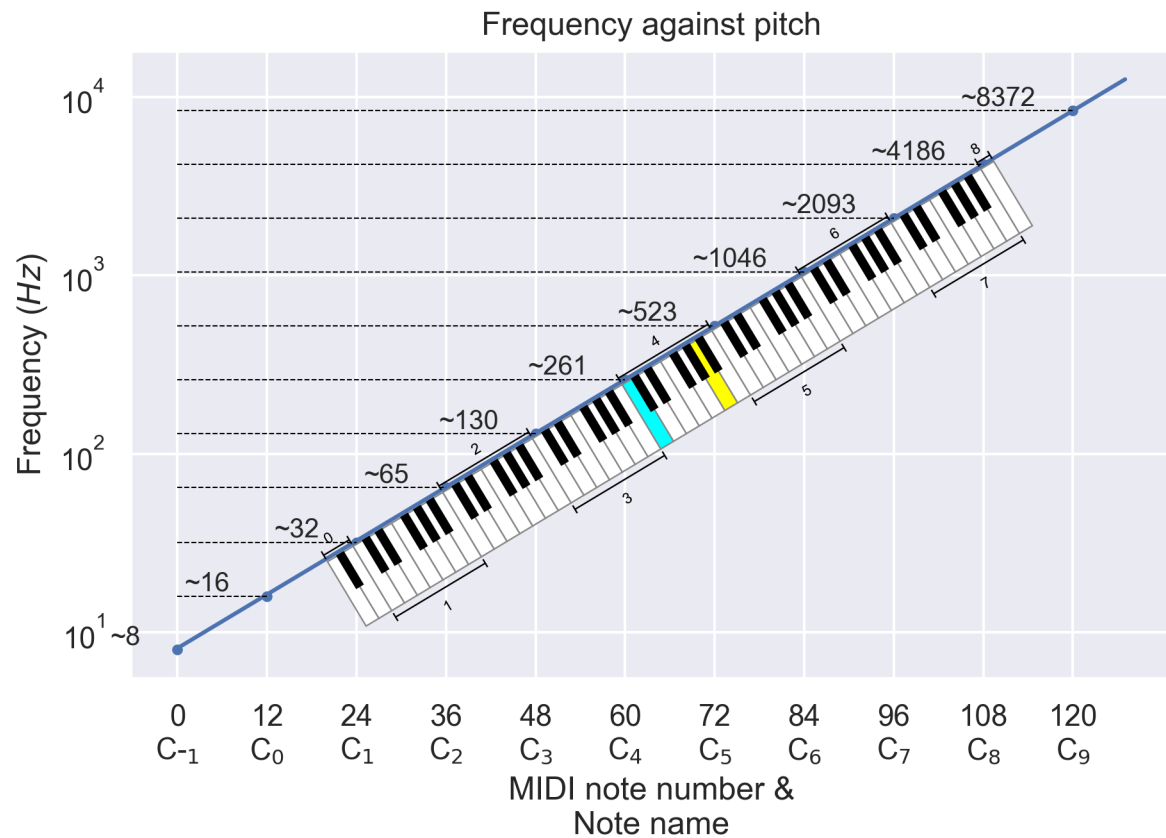
Any of the sinusoids by which a musical tone is described

## Overtone

- Any partial except the lowest
- Produces different timbres

## Fundamental frequency

The frequency of the lowest partial present



\* 88-key piano keyboard

# 01 Prepare audio files

- Trim the audio file to separate the chords out
- Normalize
- Denoise

# 03 Pick peaks (notes)

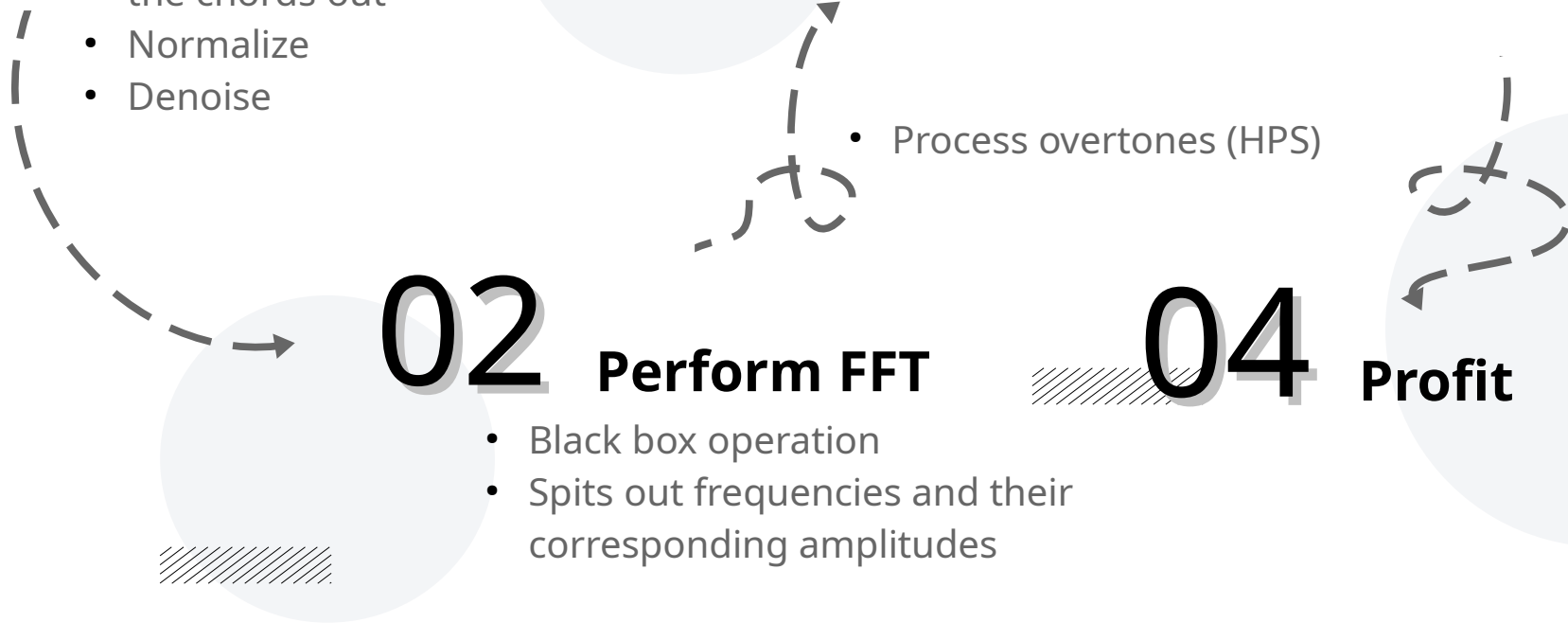
- Define a peak

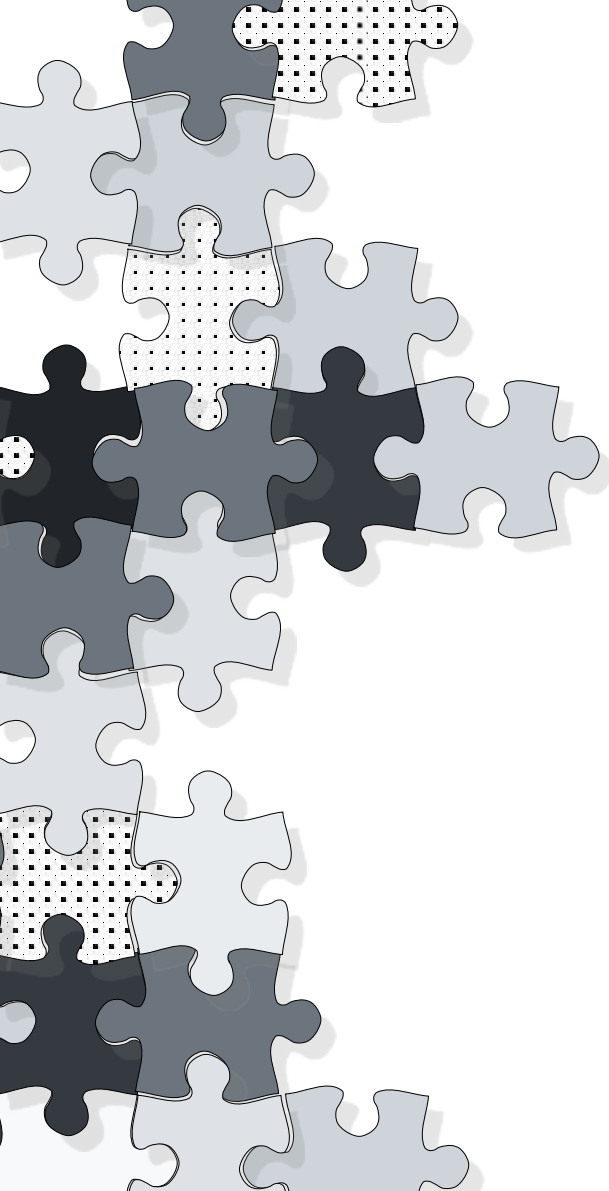
- Process overtones (HPS)

# 02 Perform FFT

- Black box operation
- Spits out frequencies and their corresponding amplitudes

# 04 Profit





# Examples

An overview of how well different types of signals work



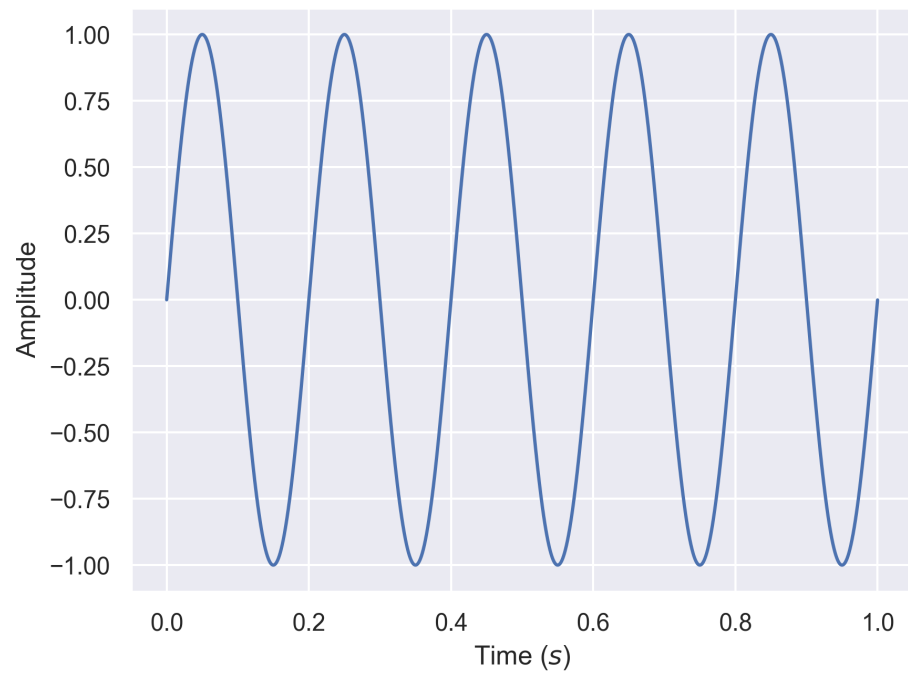


# 1. Synthetic Wave

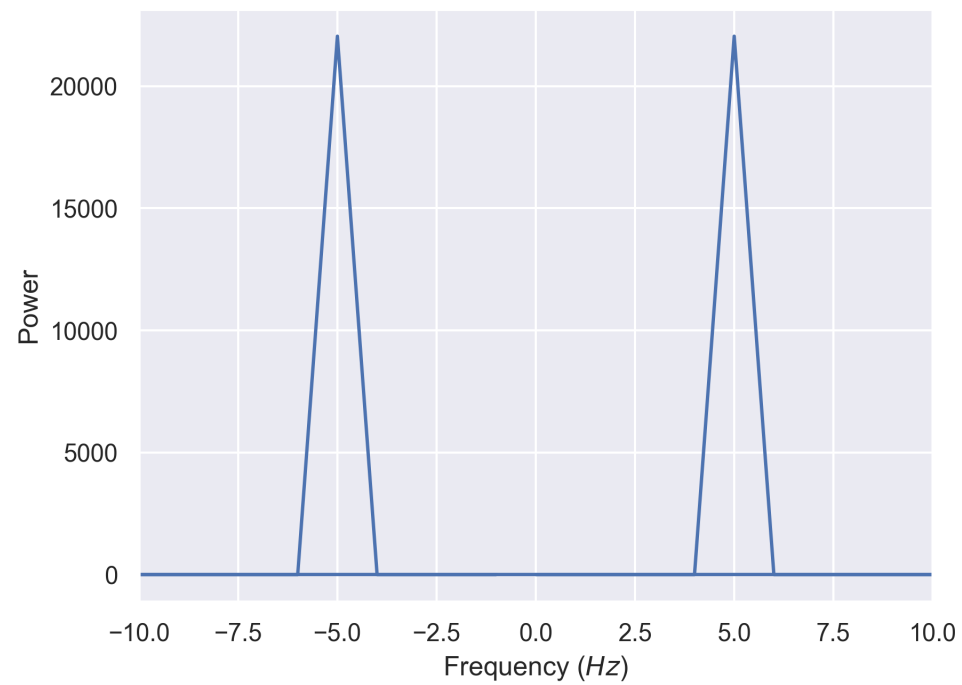




5 Hz Sine Wave



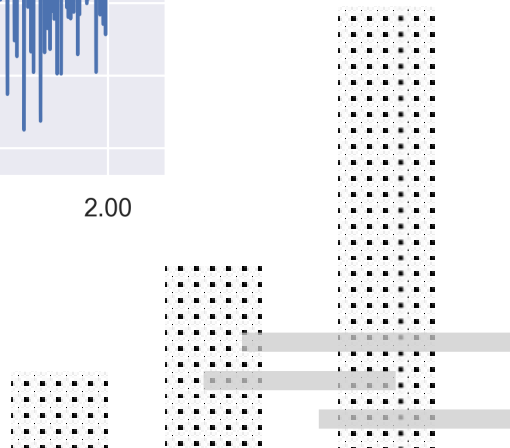
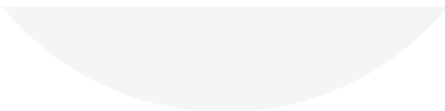
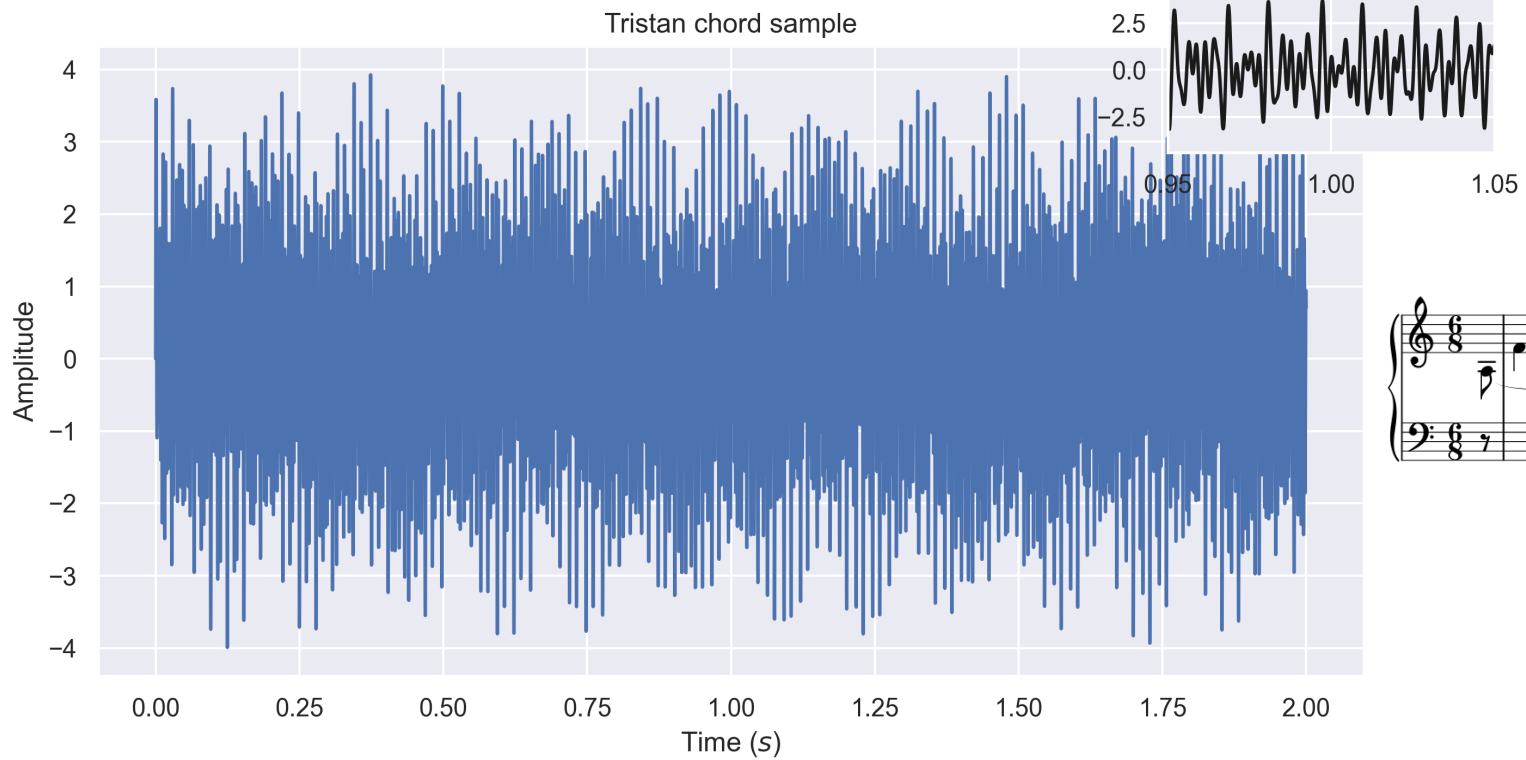
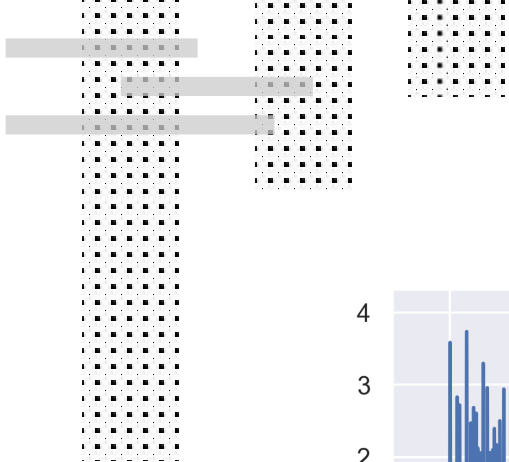
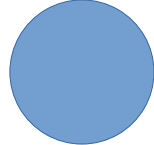
FFT on 5 Hz Sine Wave

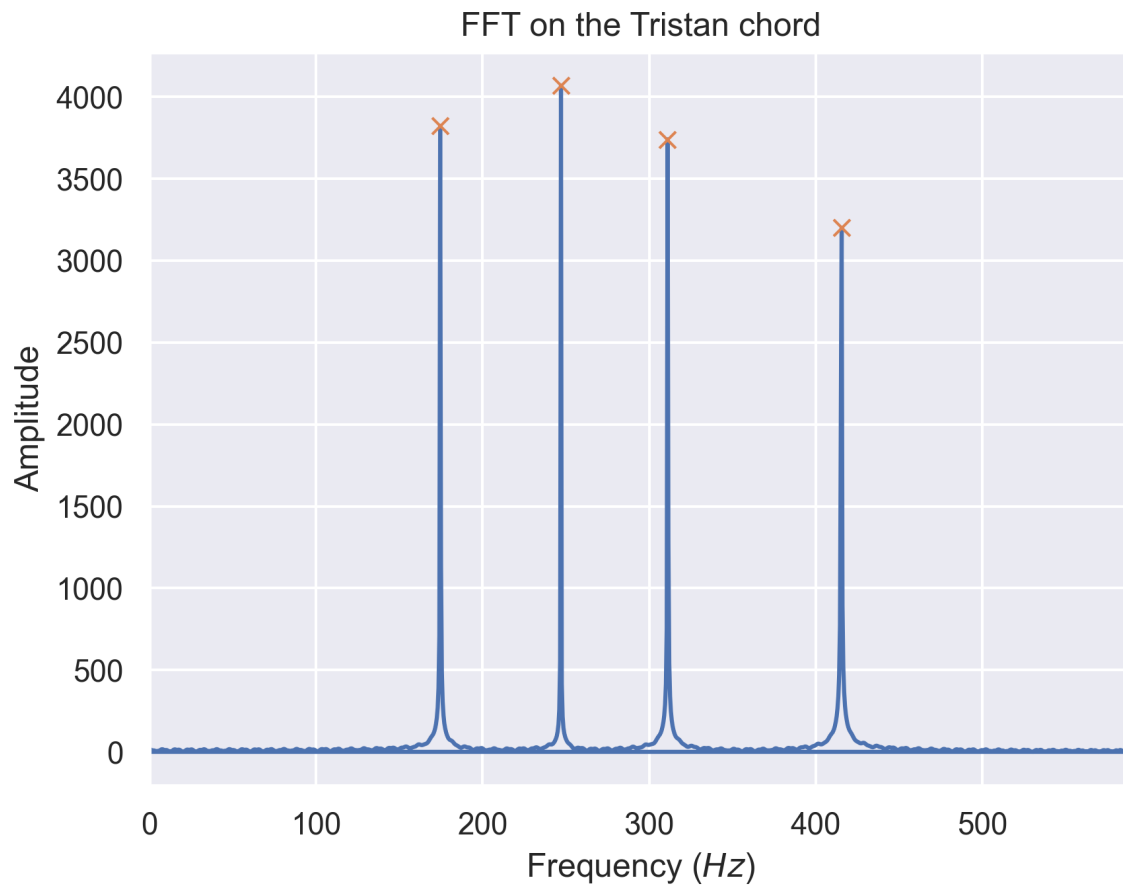


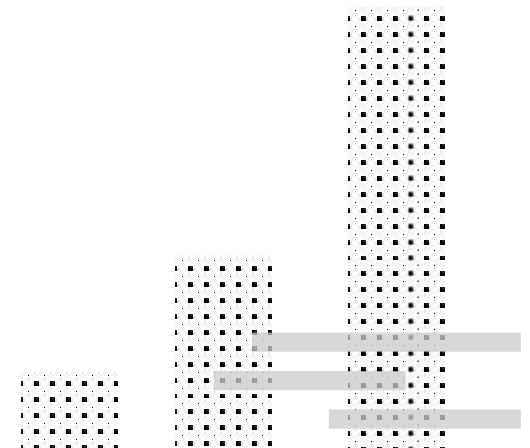
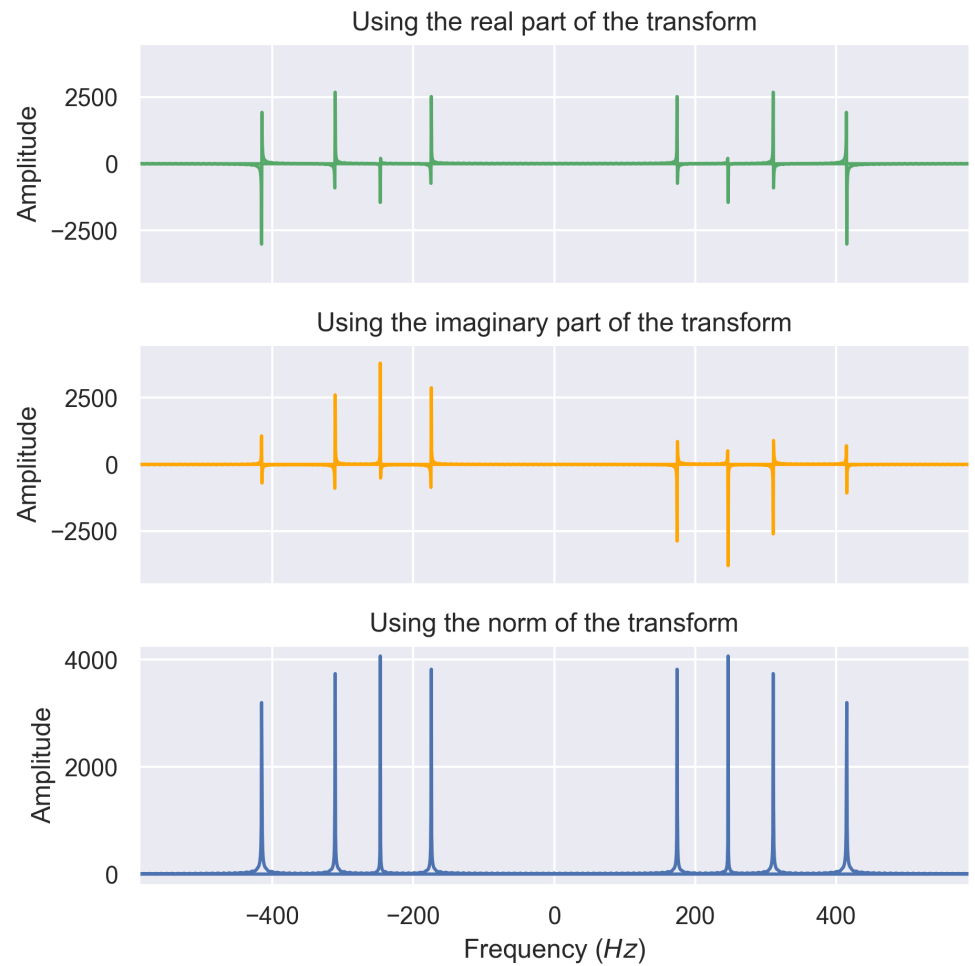
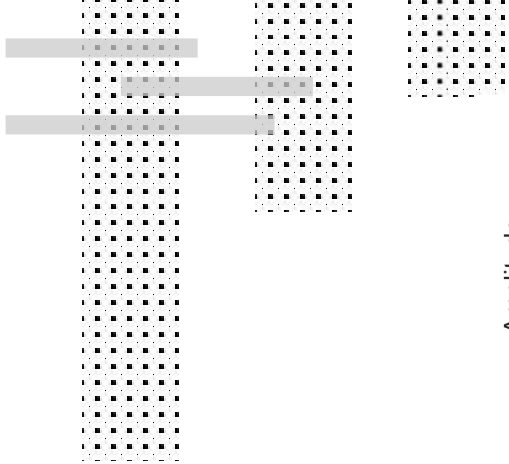


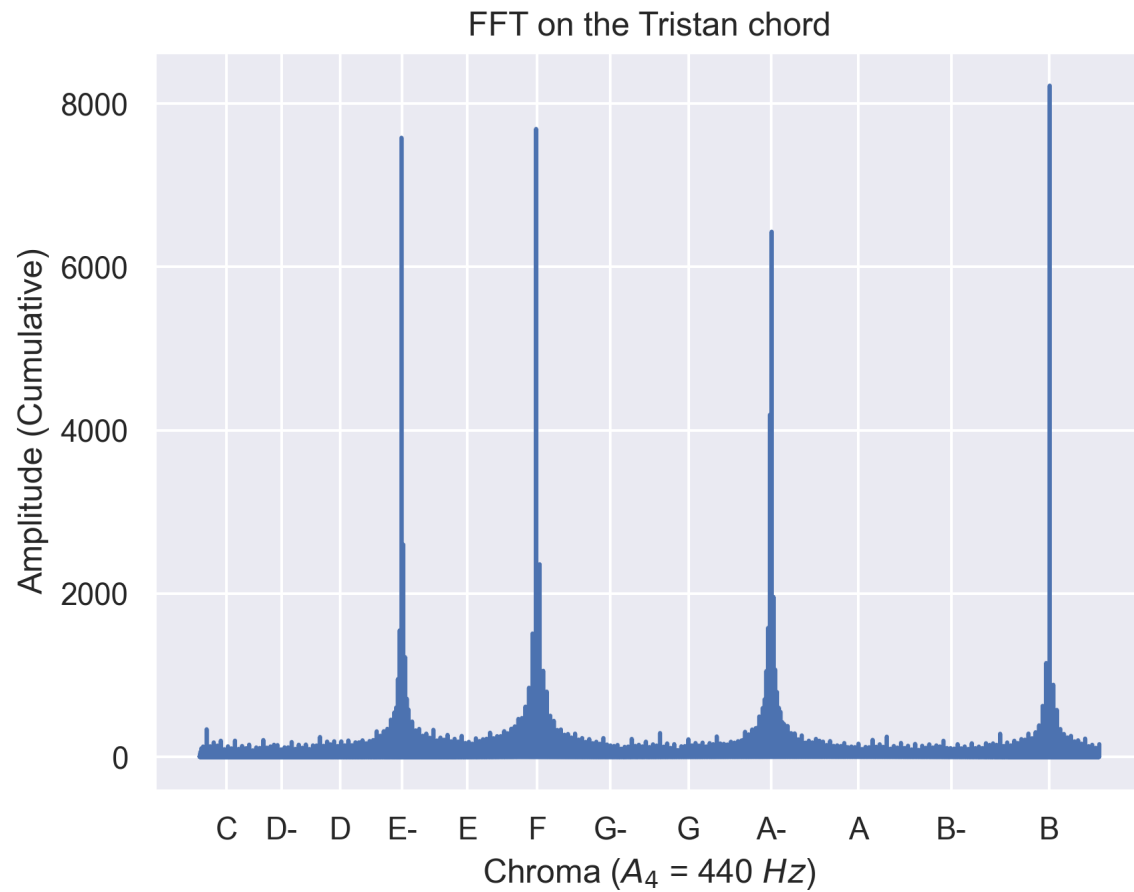
## 2. Synthetic Chord









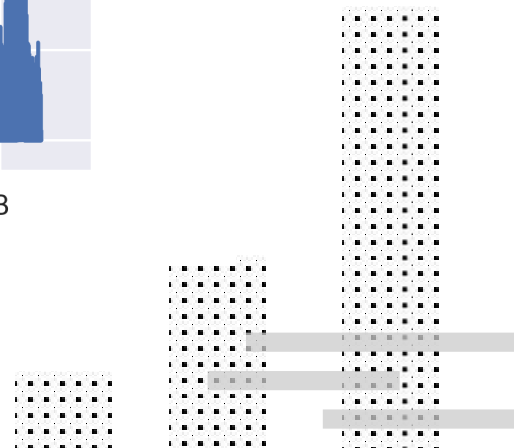
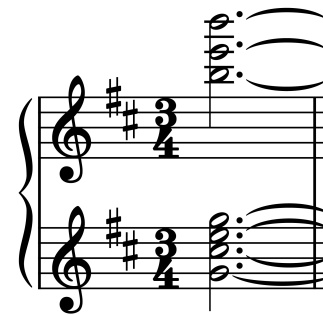
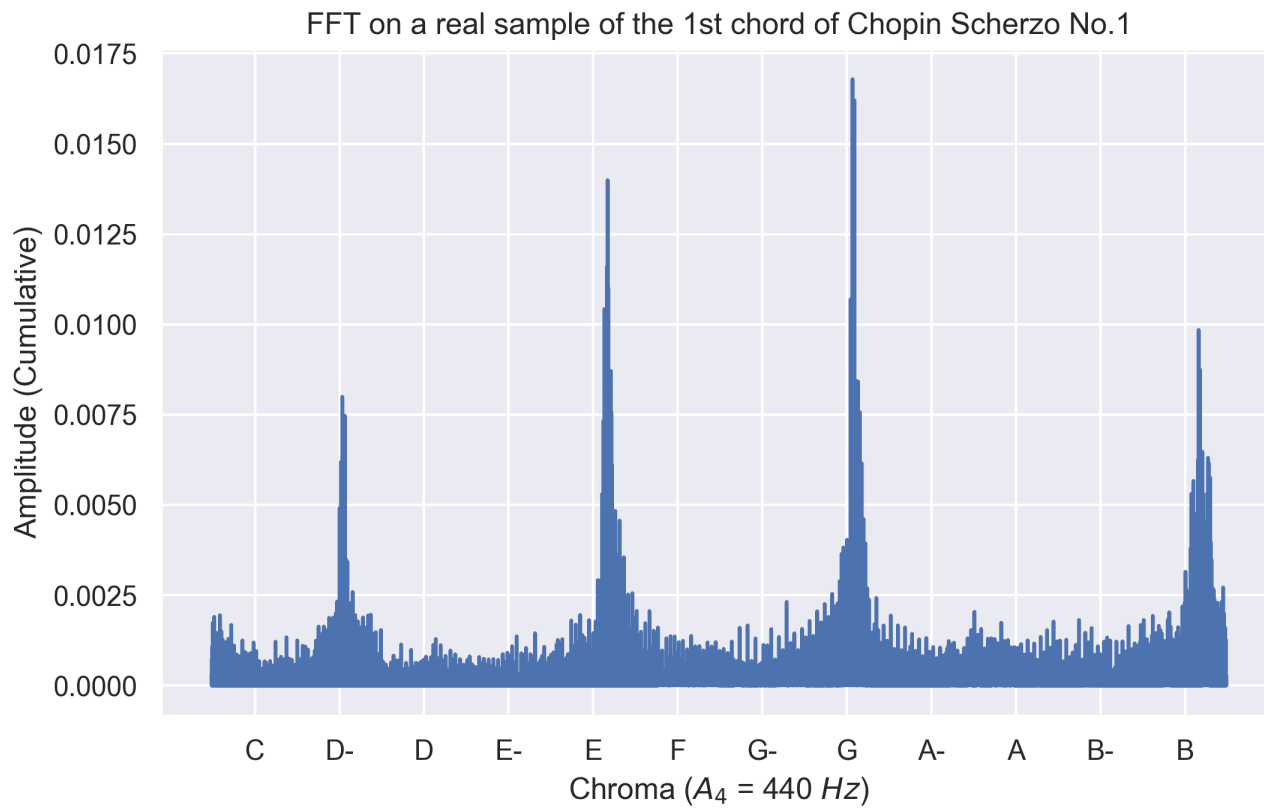
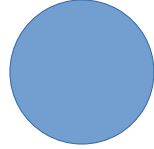
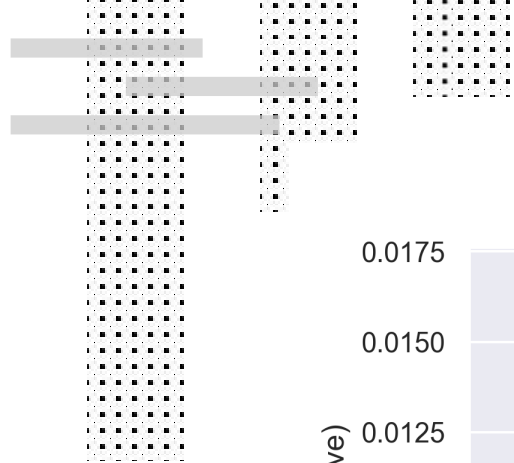


\* Info about the octave number is lost

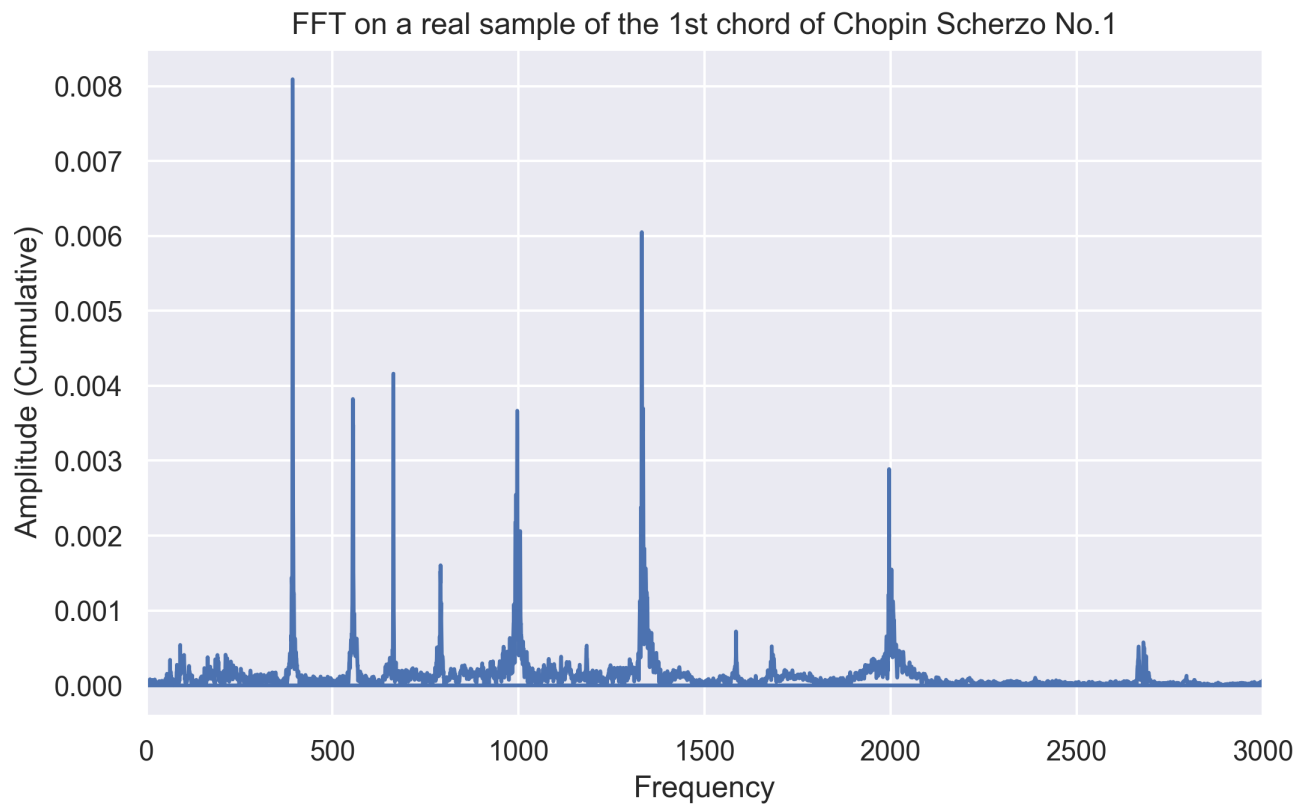


### **3. Real Chord (Piano)**





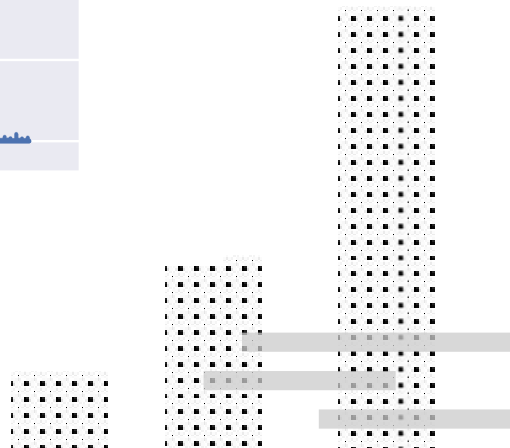
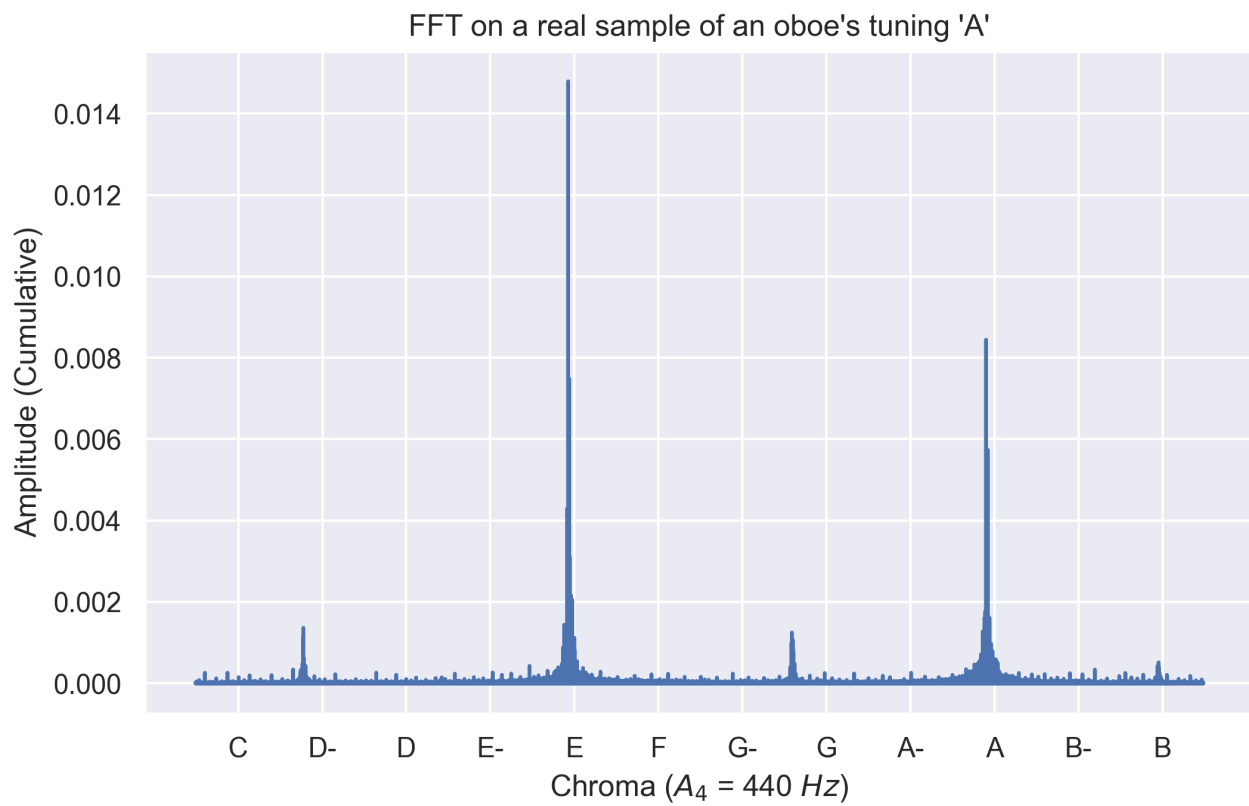
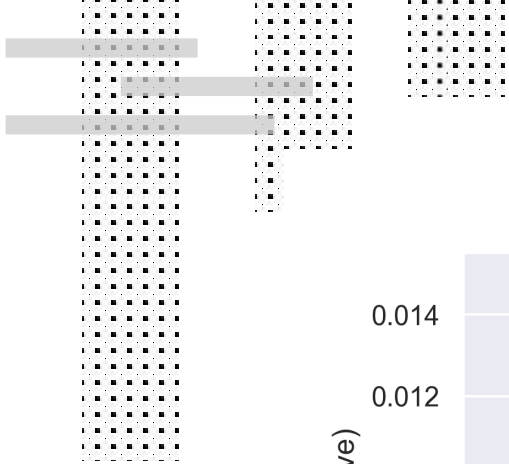
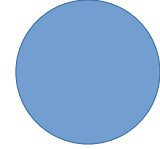


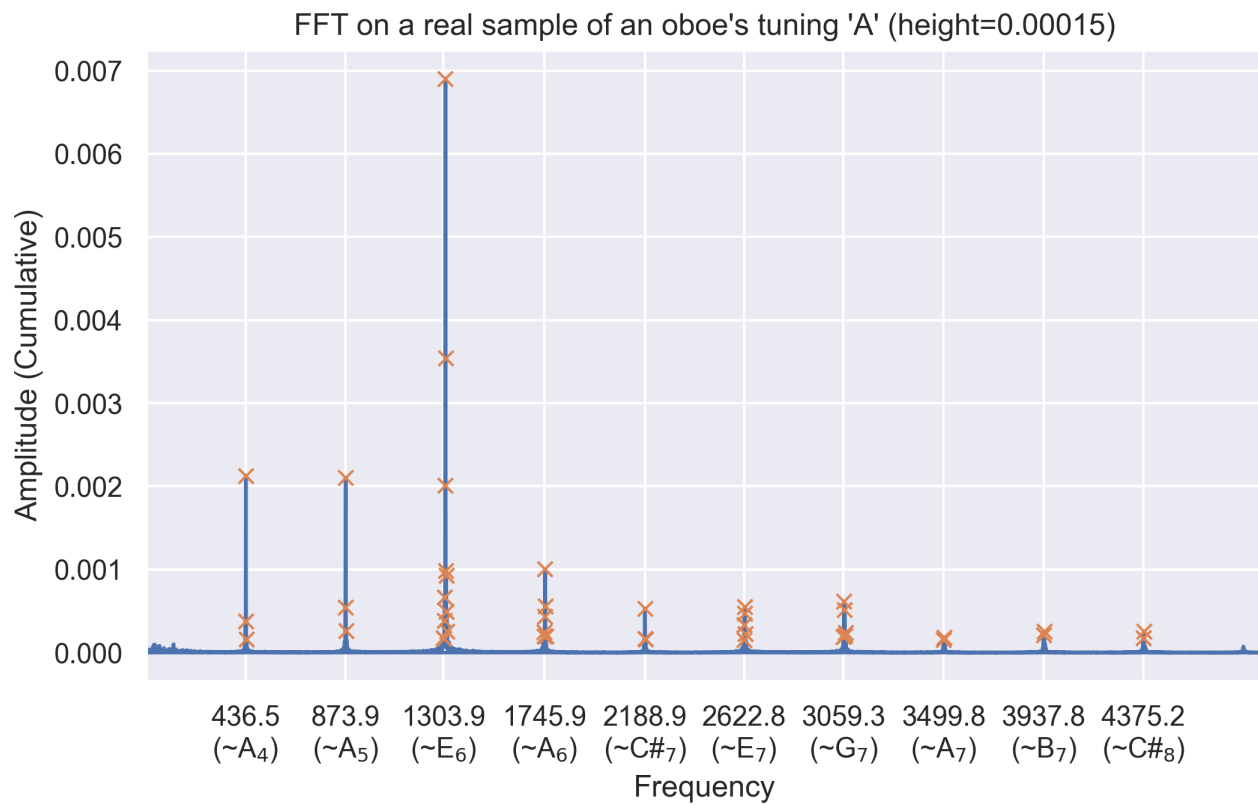




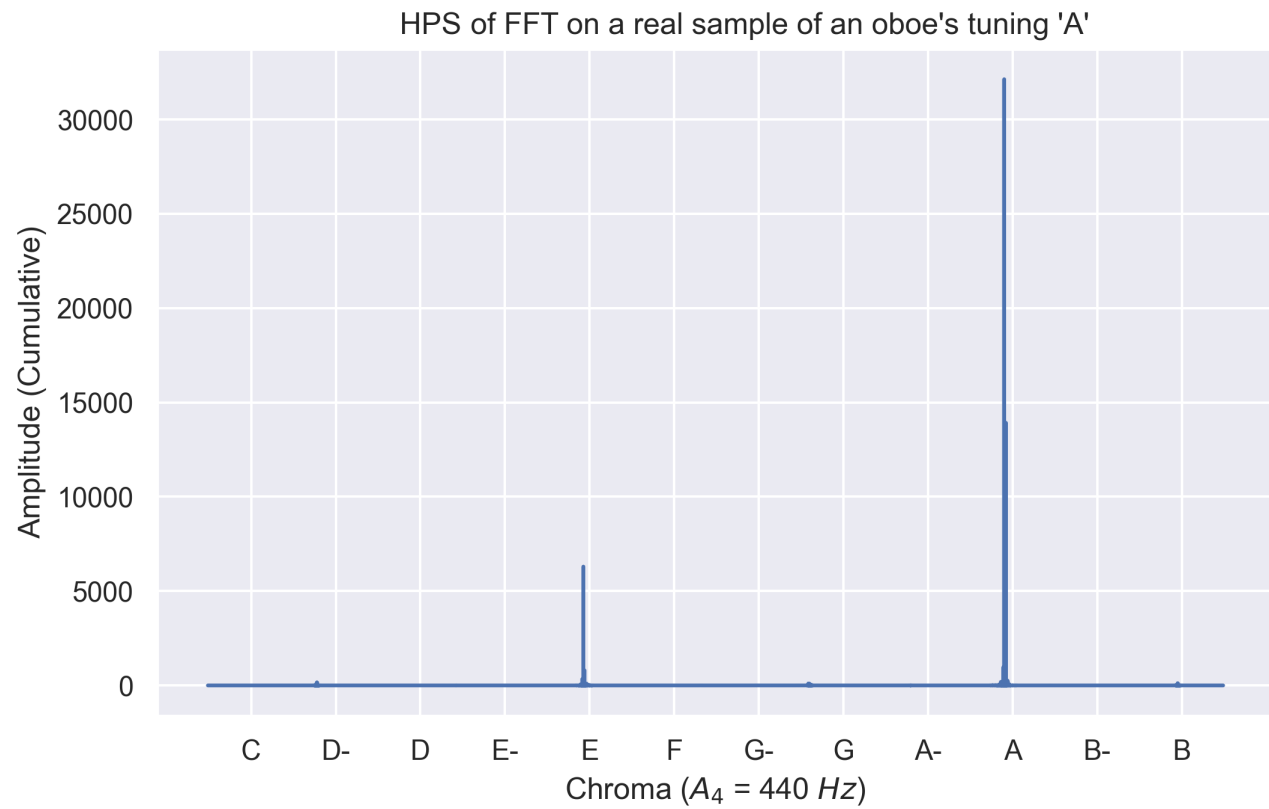
## 4. Real Note (Oboe)





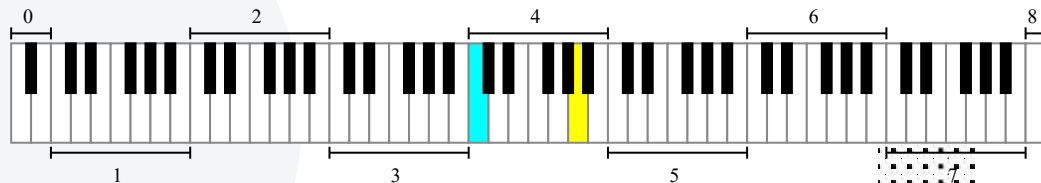


\* Many unnecessary peaks are present!



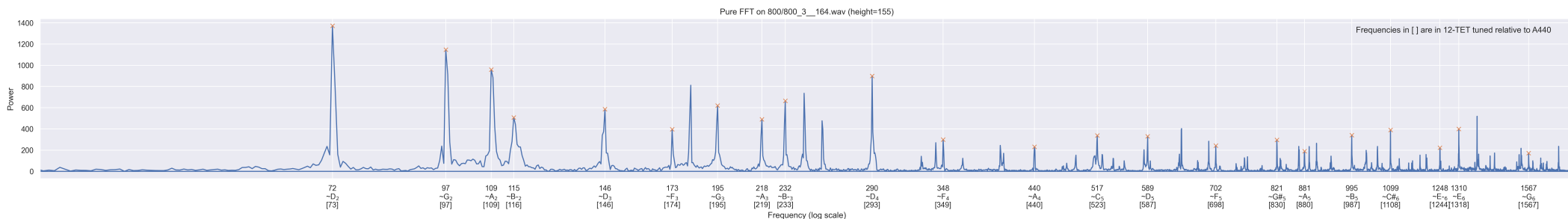
# Optimizing chord recognition through pure FFT by considering a simple case

- No overtone analysis (HPS)
  - Consider chords within an octave (only fundamental frequencies)
- Improve peak-picking method
- Semi-real piano chords
  - 3-note
  - 100 random chords per octave number (0-7)
  - Can be verified easily without labelling

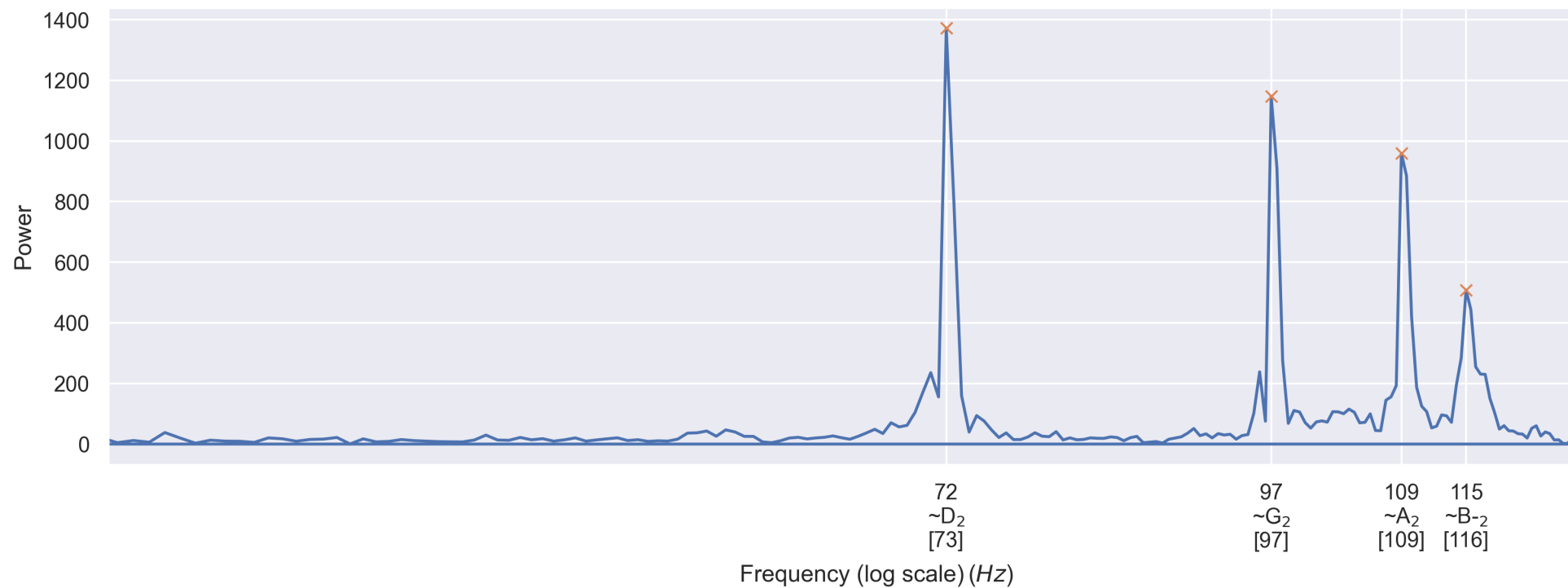
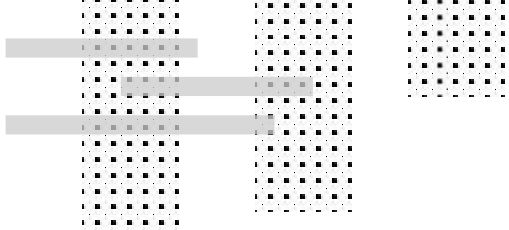


# Result:

495/800 = 61.875 %



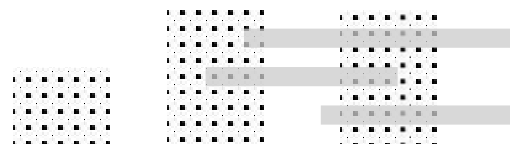
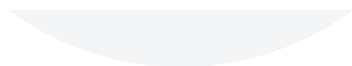
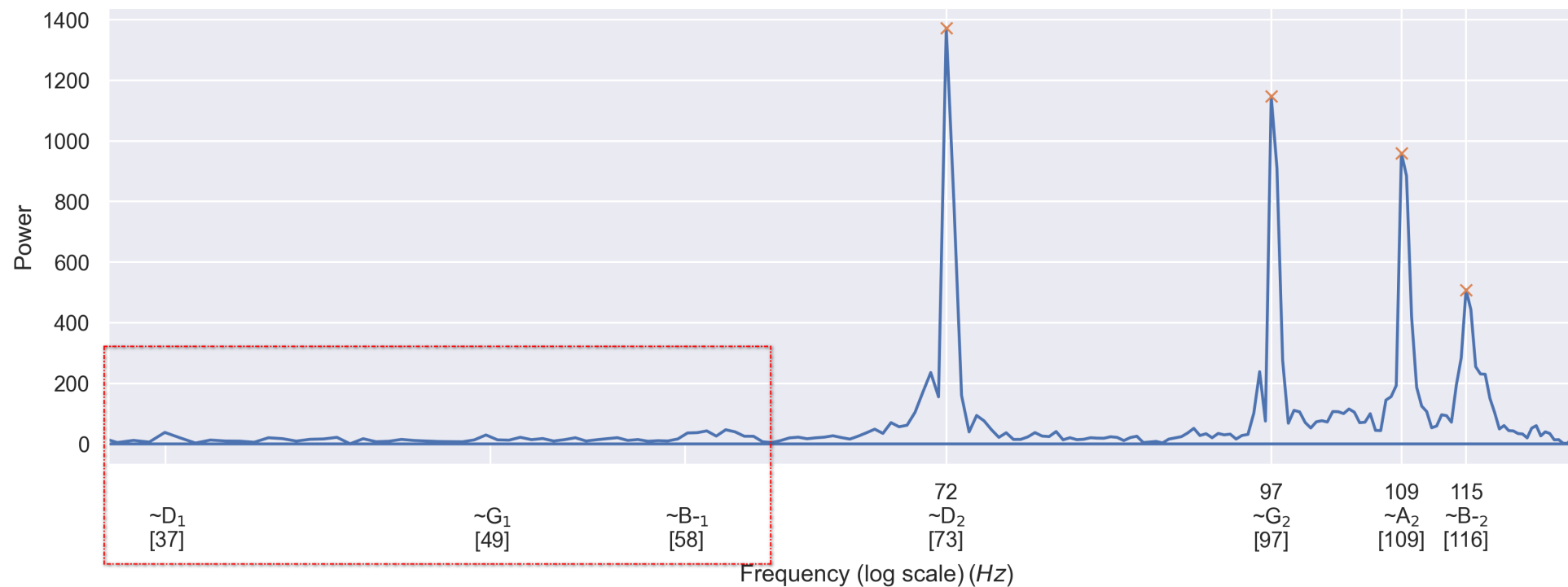
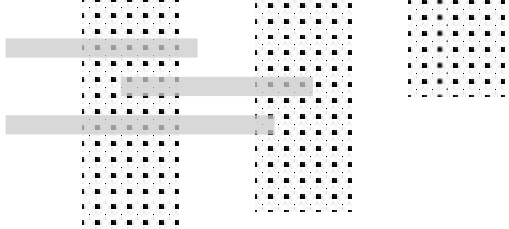
```
161: True chord: ['D1', 'F#1', 'G#1'] Identified chord: ['D2', 'F#2', 'G#2']
162: True chord: ['C#1', 'F#1', 'B-1'] Identified chord: ['C#2', 'F#2', 'G#2']
163: True chord: ['E1', 'F#1', 'B1'] Identified chord: ['B1', 'E2', 'F#2']
164: True chord: ['D1', 'G1', 'B-1'] Identified chord: ['D2', 'G2', 'A2']
165: True chord: ['C1', 'E1', 'G1'] Identified chord: ['E2', 'G2', 'B2']
166: True chord: ['C#1', 'E1', 'B1'] Identified chord: ['B1', 'C#2', 'E2']
167: True chord: ['C1', 'G1', 'B1'] Identified chord: ['B1', 'G2', 'B2']
168: True chord: ['C1', 'E-1', 'A1'] Identified chord: ['E-2', 'G2', 'A2']
169: True chord: ['C1', 'E-1', 'B1'] Identified chord: ['B1', 'E-2', 'G2']
```

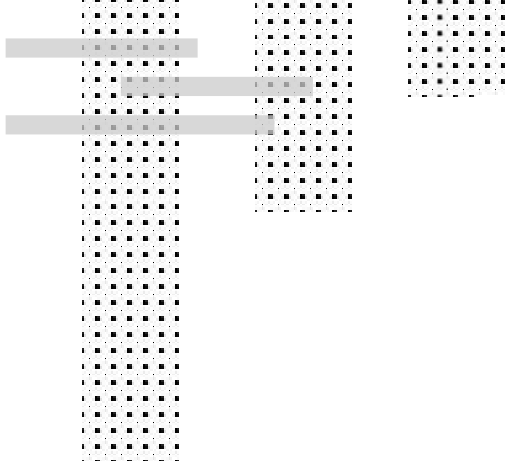


\* Unnecessary peaks are not present anymore!









Note count against octave number

