

interaction

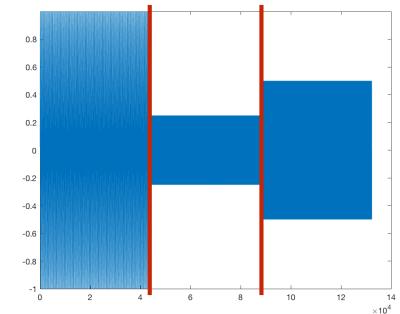
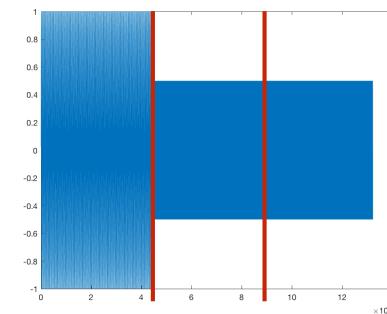
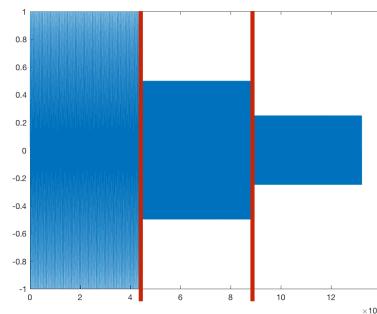
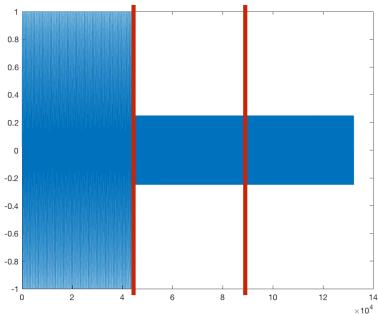


150 Hz

1000 Hz

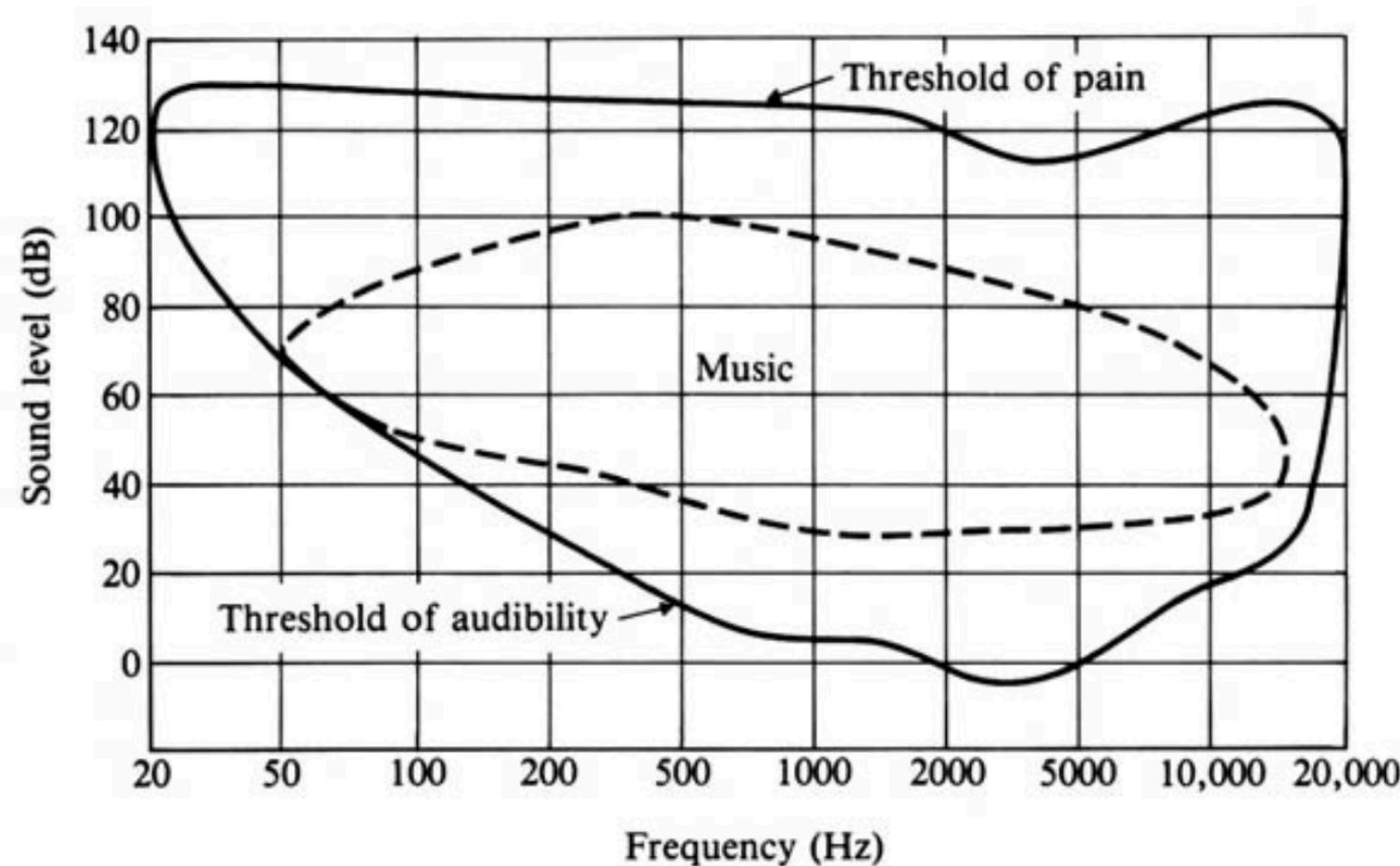
5000 Hz

Which sine wave sounds louder?



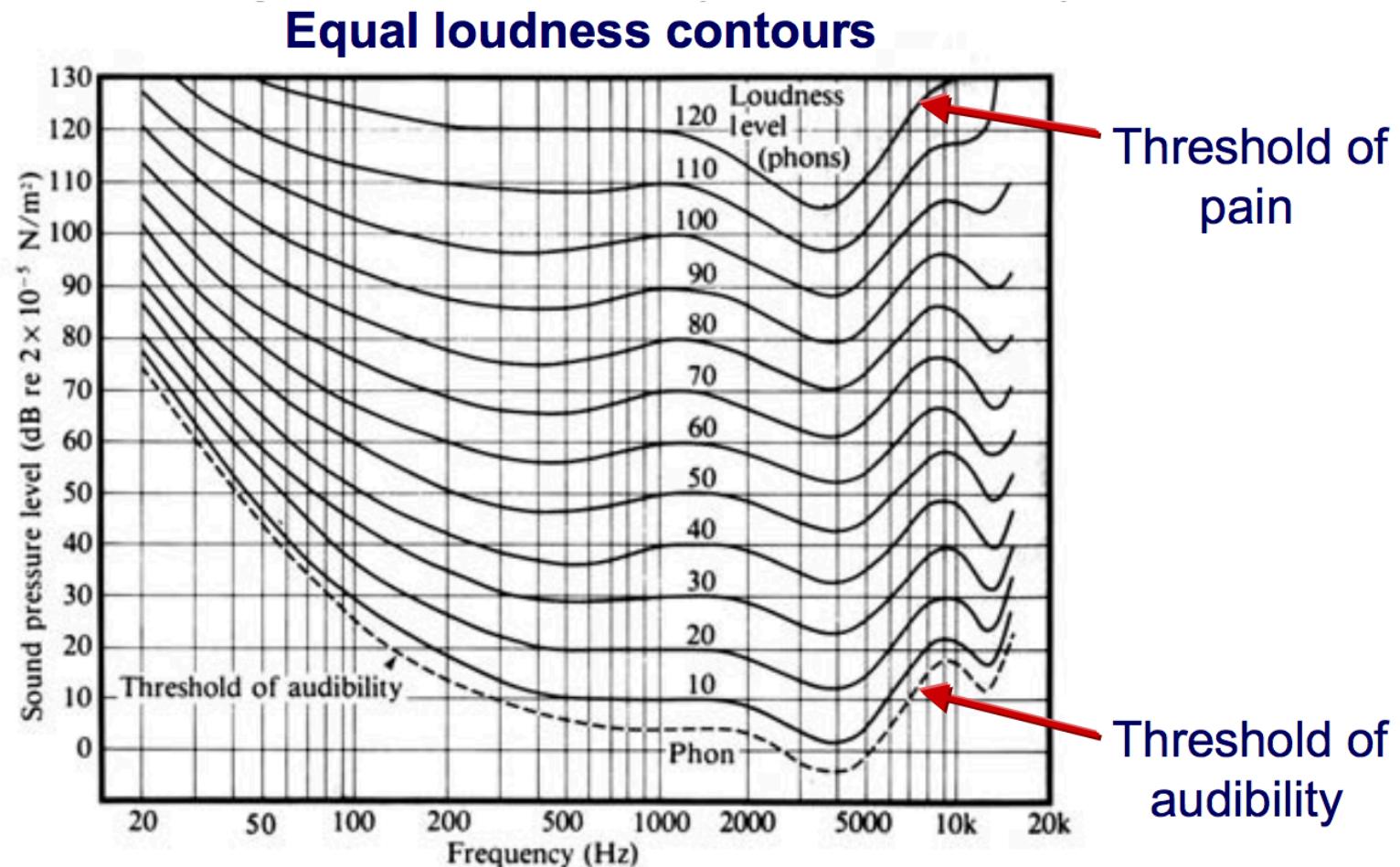
Hearing Sensitivity

- sounds targeted to humans go well with the properties of hearing



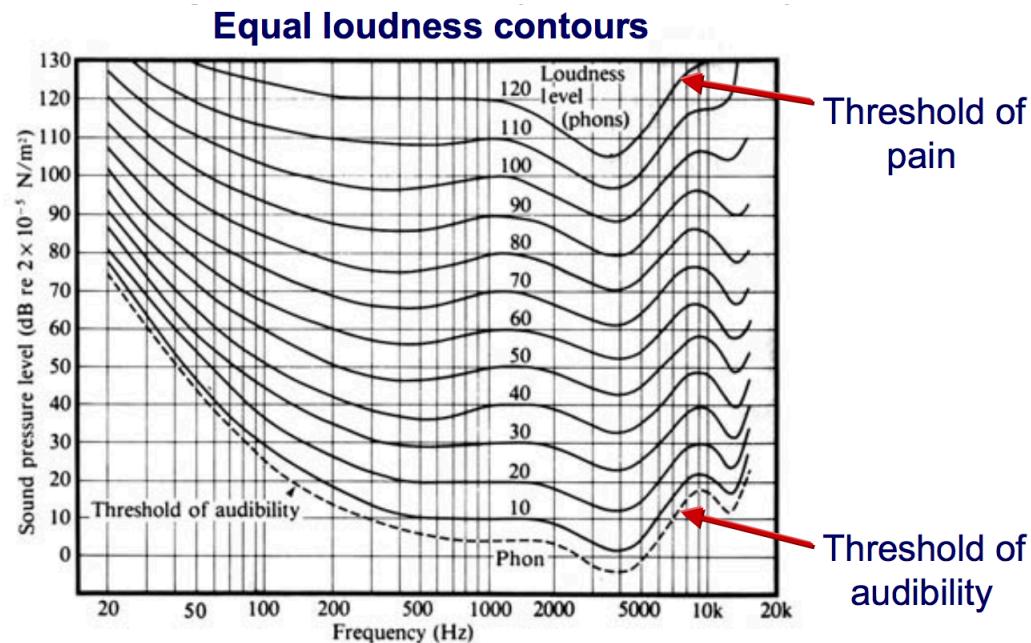
Hearing Sensitivity

- sensitivity of hearing depends heavily in frequency
- contours are based on psychoacoustic studies using sine tones



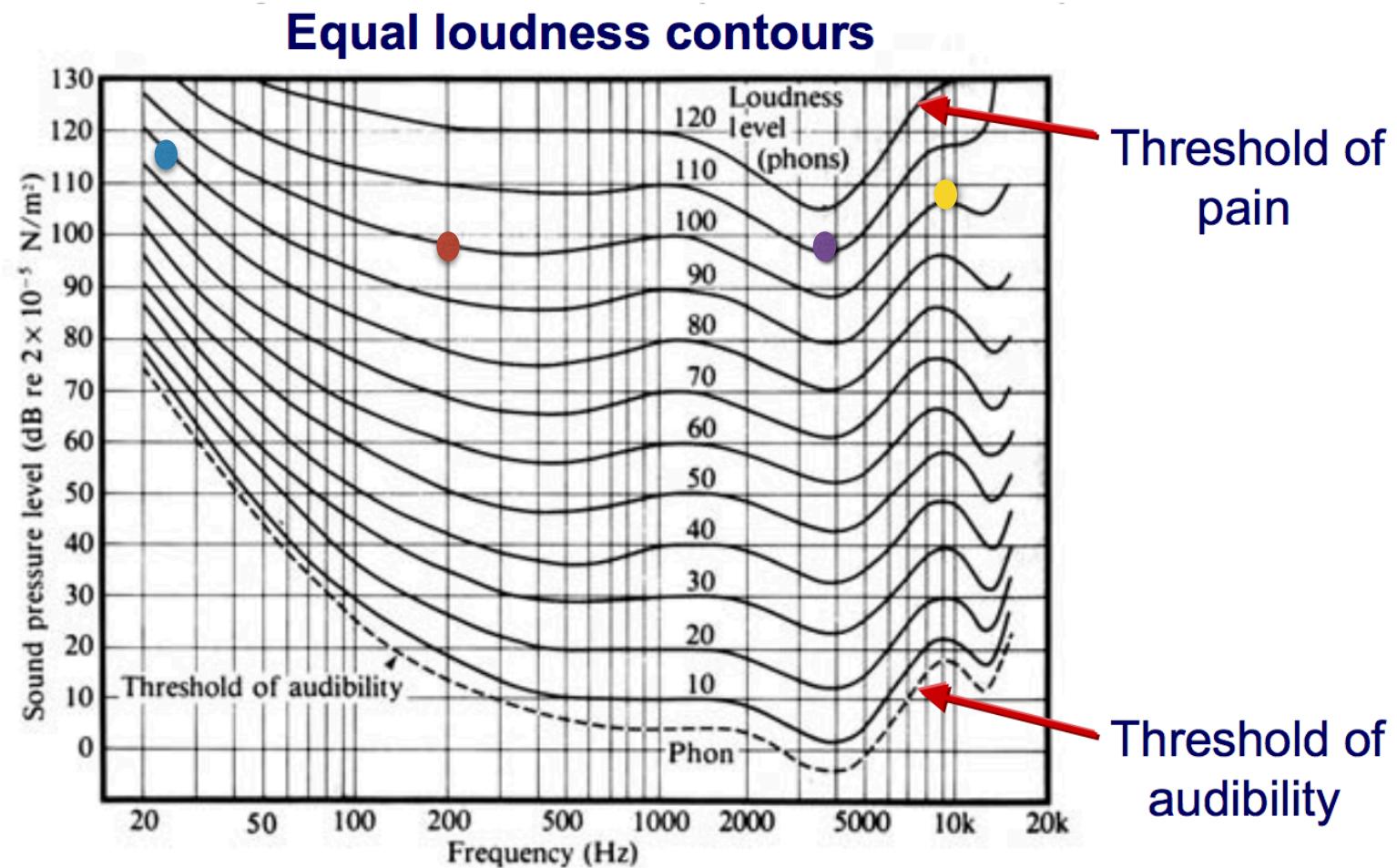
Hearing Sensitivity

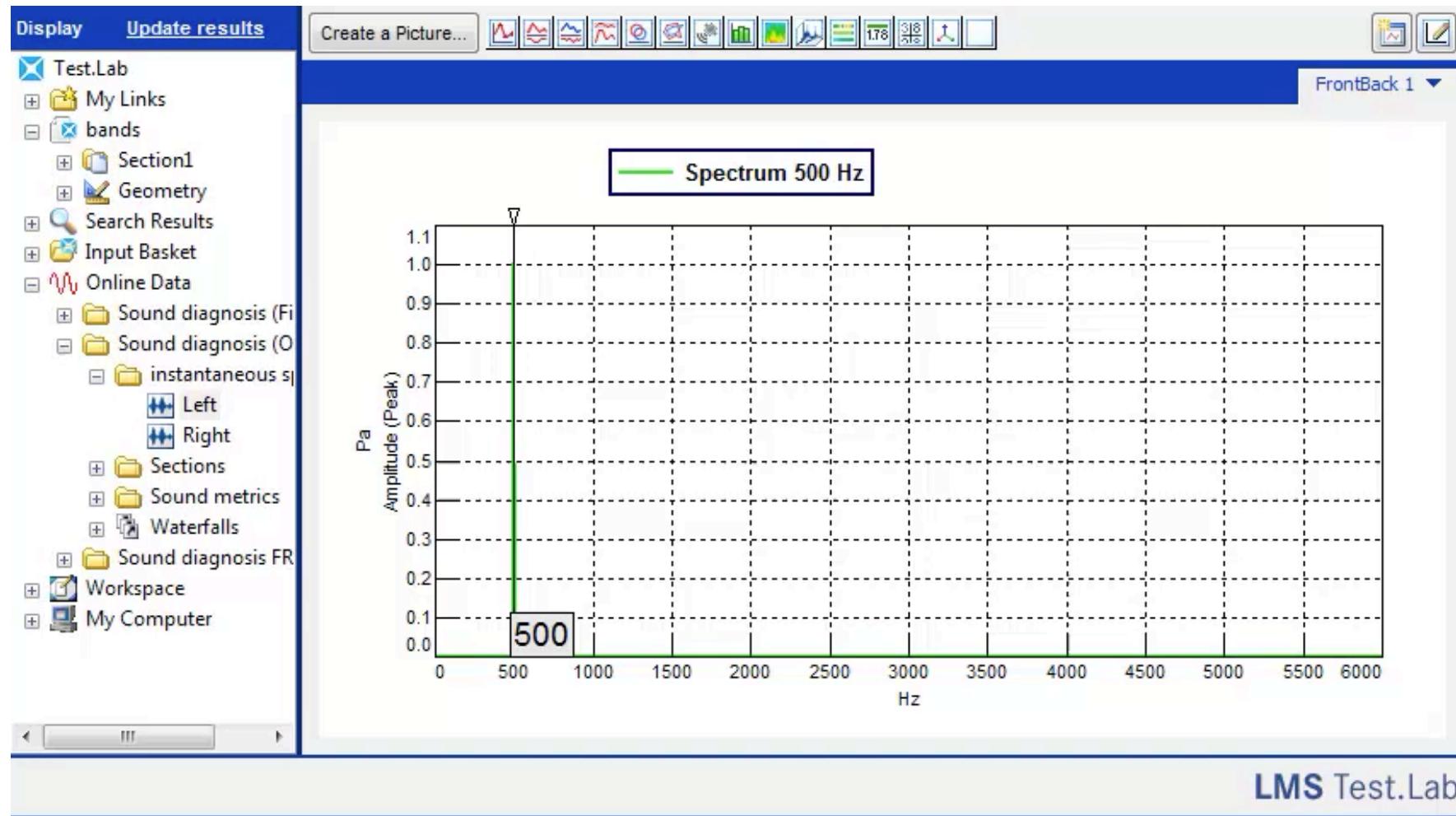
- ear most sensitive in the 1kHz-5kHz range
- absolute threshold of human hearing determined by human testing (describes energy in a pure/sine tone needed for audibility in a noiseless environment)
- phons = units of perceptual amplitude



Hearing Sensitivity

- which tone would be the loudest?

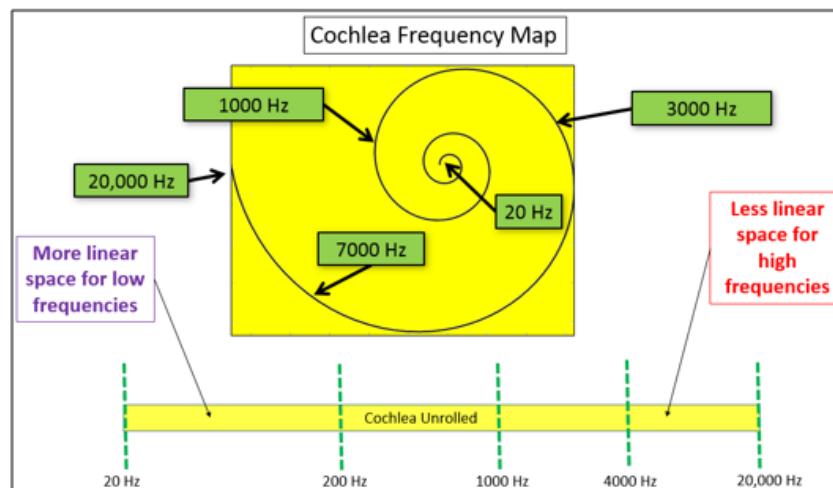




- ex: 20 Hertz difference between 500 and 520 Hertz tones more readily than a 5000 and 5020 Hertz tones.

Critical Bands

- human ear can hear from 20 to 20,000 Hertz - finer low frequency discrimination vs high frequencies
- ability to distinguish individual tones varies as a function of frequency
- hearing “bands” - used to quantify the ability of the human ear to distinguish between individual frequency tones
- loud response at one place on the basal membrane will mask softer response in the critical band around it

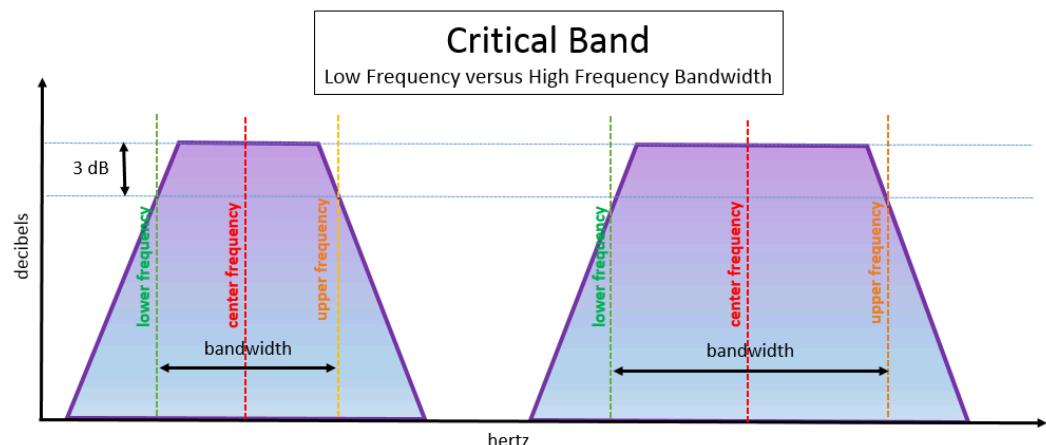


<https://www.szynalski.com/tone-generator/>

- ex: 10 Hertz difference around 300 and around 3000 Hz

Critical Bands

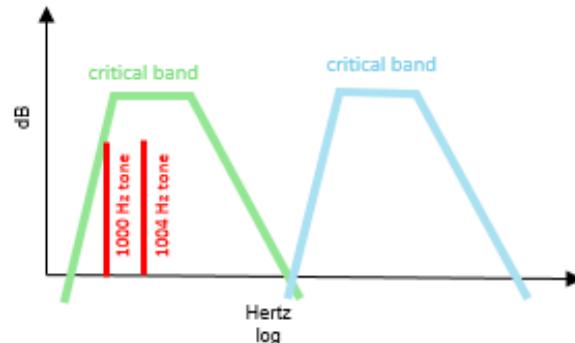
- any audible tone will create a critical band centred around it
- a pure tone (single line in the spectrum) can be represented by a psychological masking curve
- critical bands important (in perceptual coding) - they show that the ear discriminates between energy in and outside the band resulting in masking
- a critical band is the BW at which subjective responses change



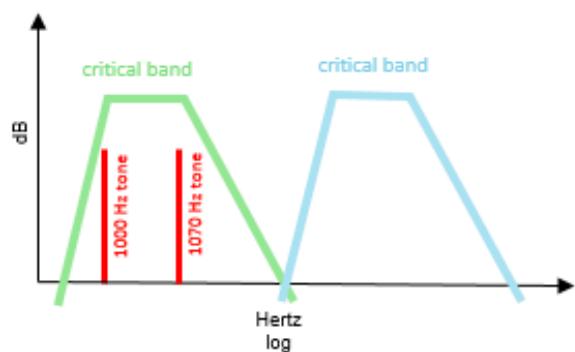
Critical Bands

- codecs rely on amplitude masking within critical bands to reduce information size
- critical bands also used to explain consonance and dissonance
 - tone intervals with a frequency difference greater than a critical band — more consonant
 - tone intervals with a frequency difference less than a critical band — more dissonant

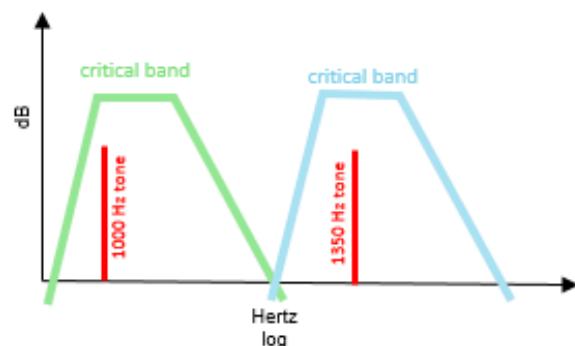
Critical Bands



- ex: tones are 4 Hertz apart - hear a single tone with a low frequency modulation or **beating**.



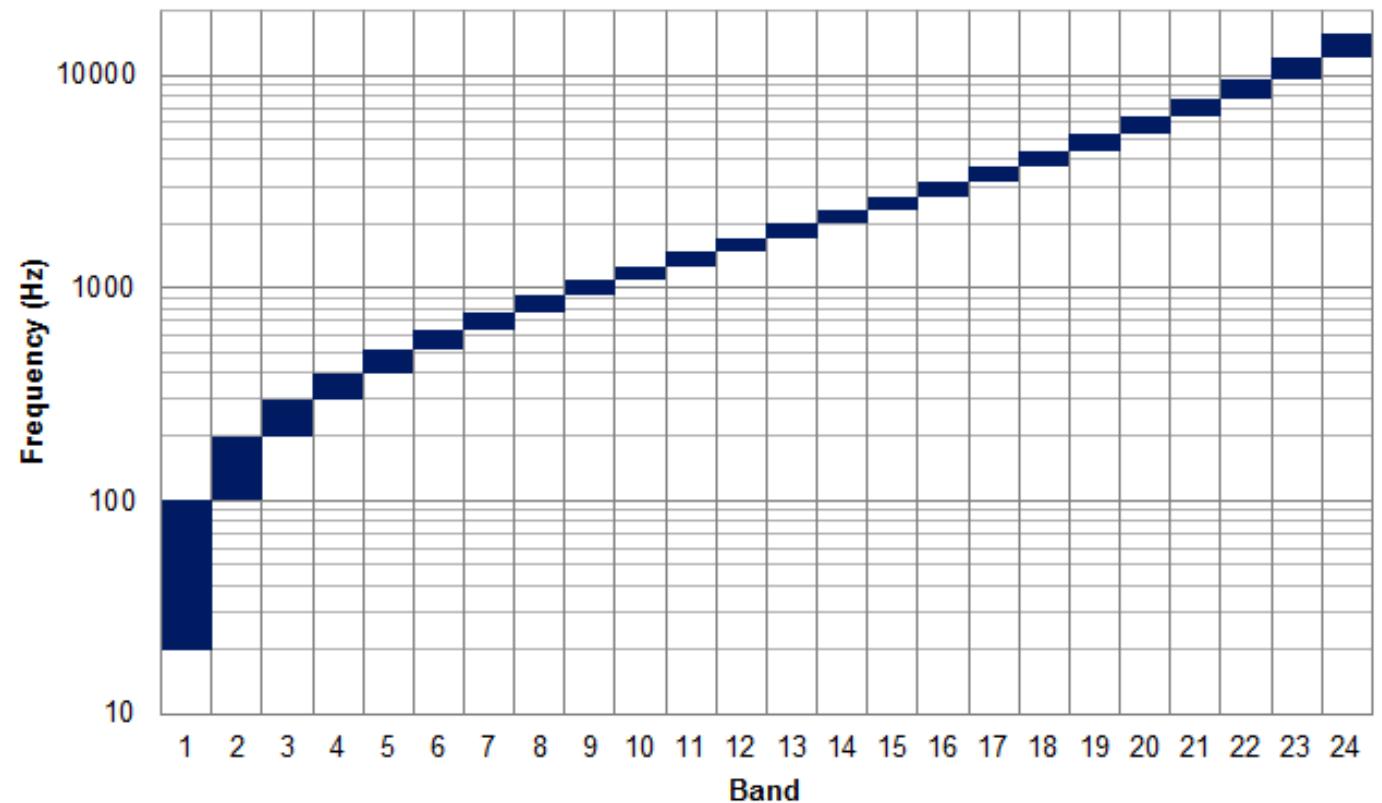
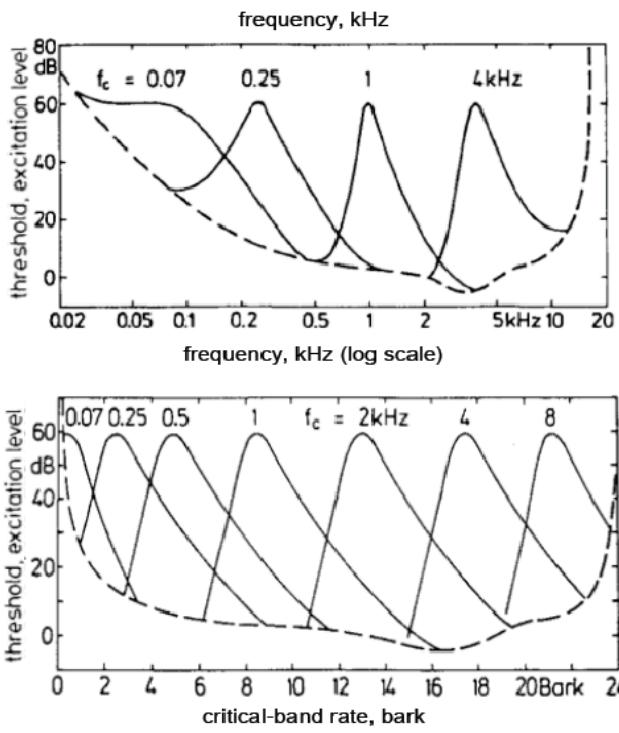
- ex: tones are about 70 Hertz apart, the ear hears a rapid modulation or beating giving rise to “roughness”



- ex: separation of 350 Hertz - tones in different critical bands - can distinguish them from each other

Critical Bands

- Bark = unit of perceptual frequency
- Using a Bark scale - physical spectrum can be converted to a psychological spectrum
- 24 critical bands of hearing



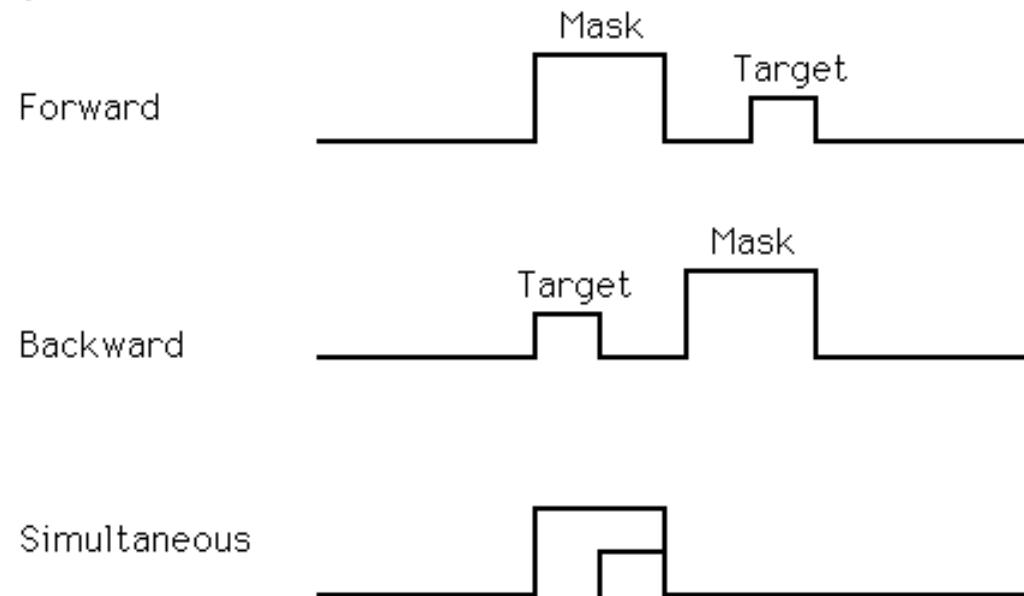
Audio Masking



Audio Masking

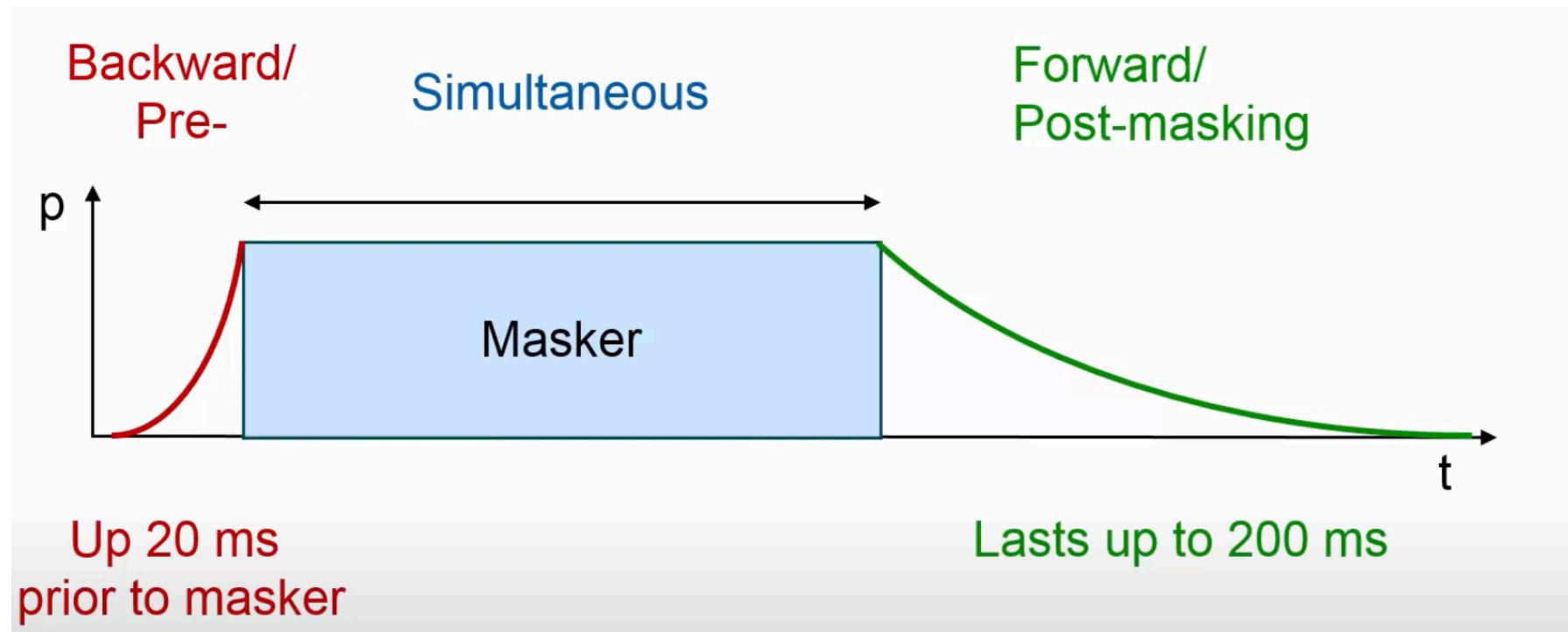
- Simultaneous masking vs temporal masking

Types of Masking



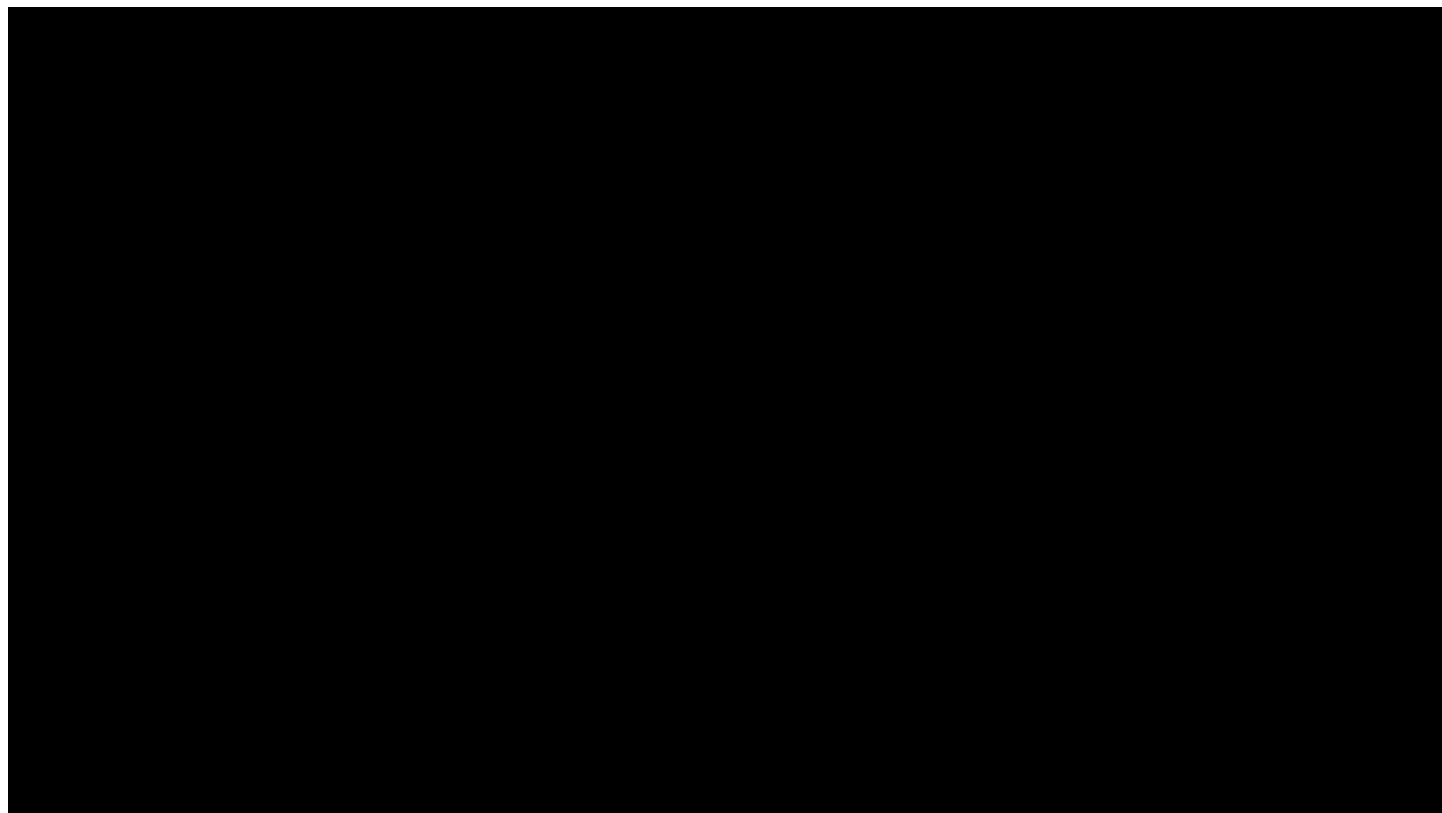
Audio Masking

- Non-Simultaneous masking/temporal masking
 - when both **do not** occur at same time



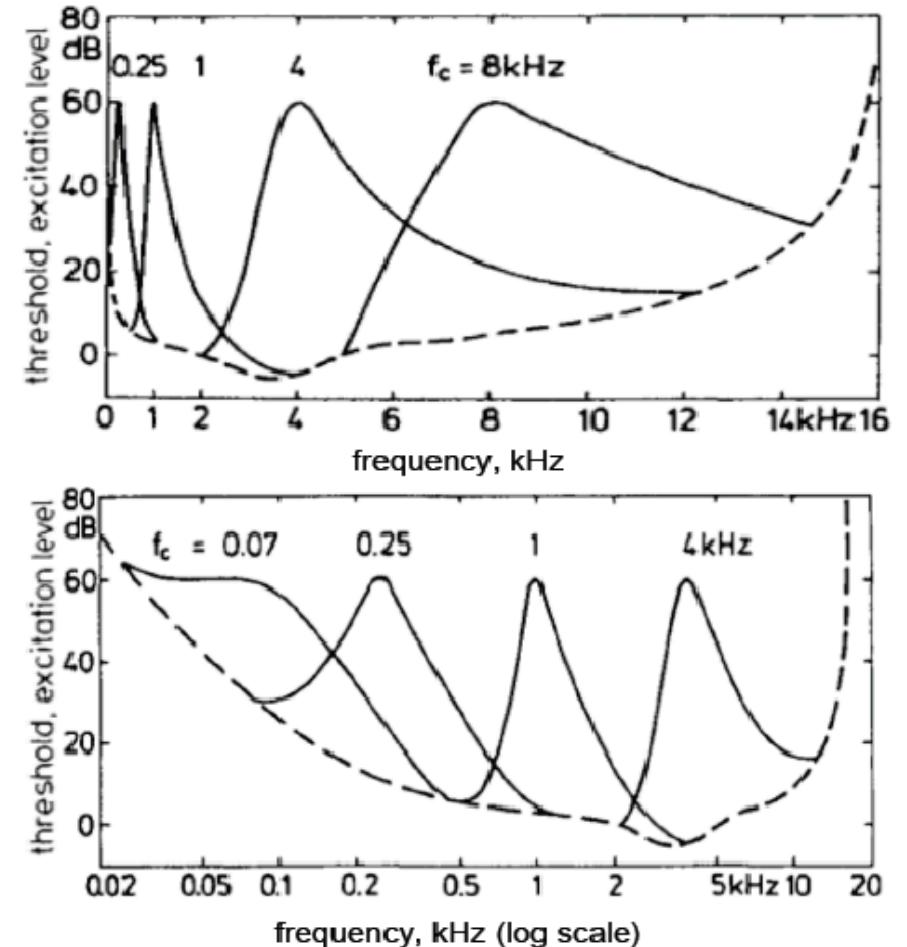
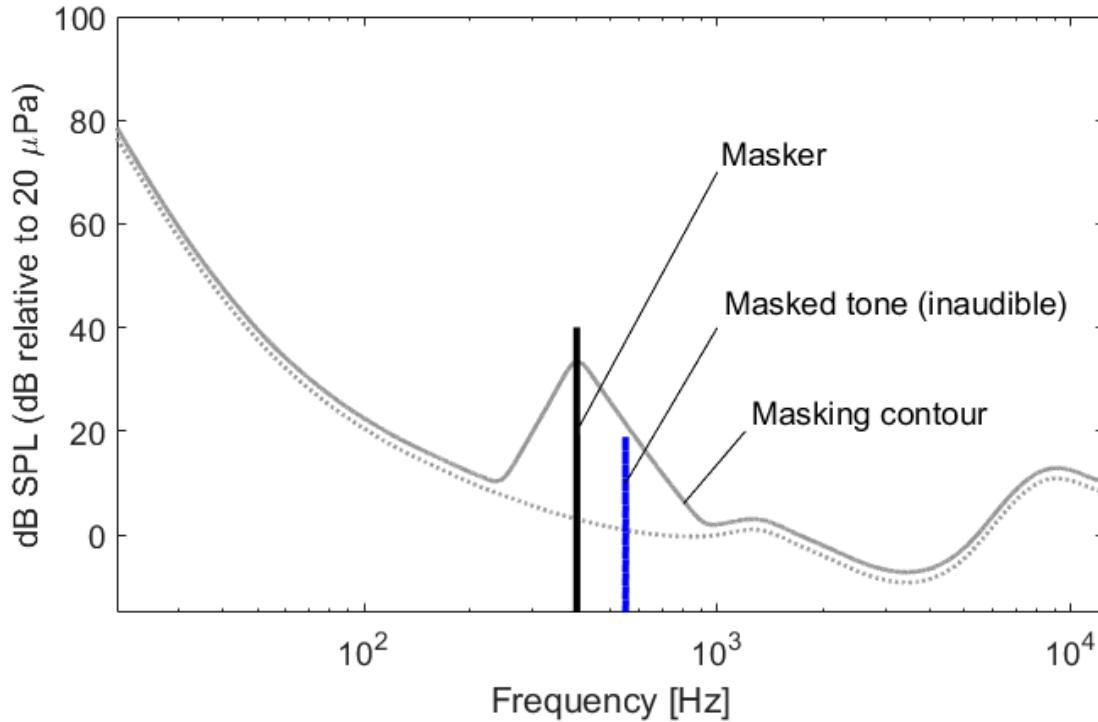
Audio Masking

- **Simultaneous masking/frequency masking**
 - when both occur at same time and close in frequency
 - a loud response on the basilar membrane will mask softer responses in the critical band around it



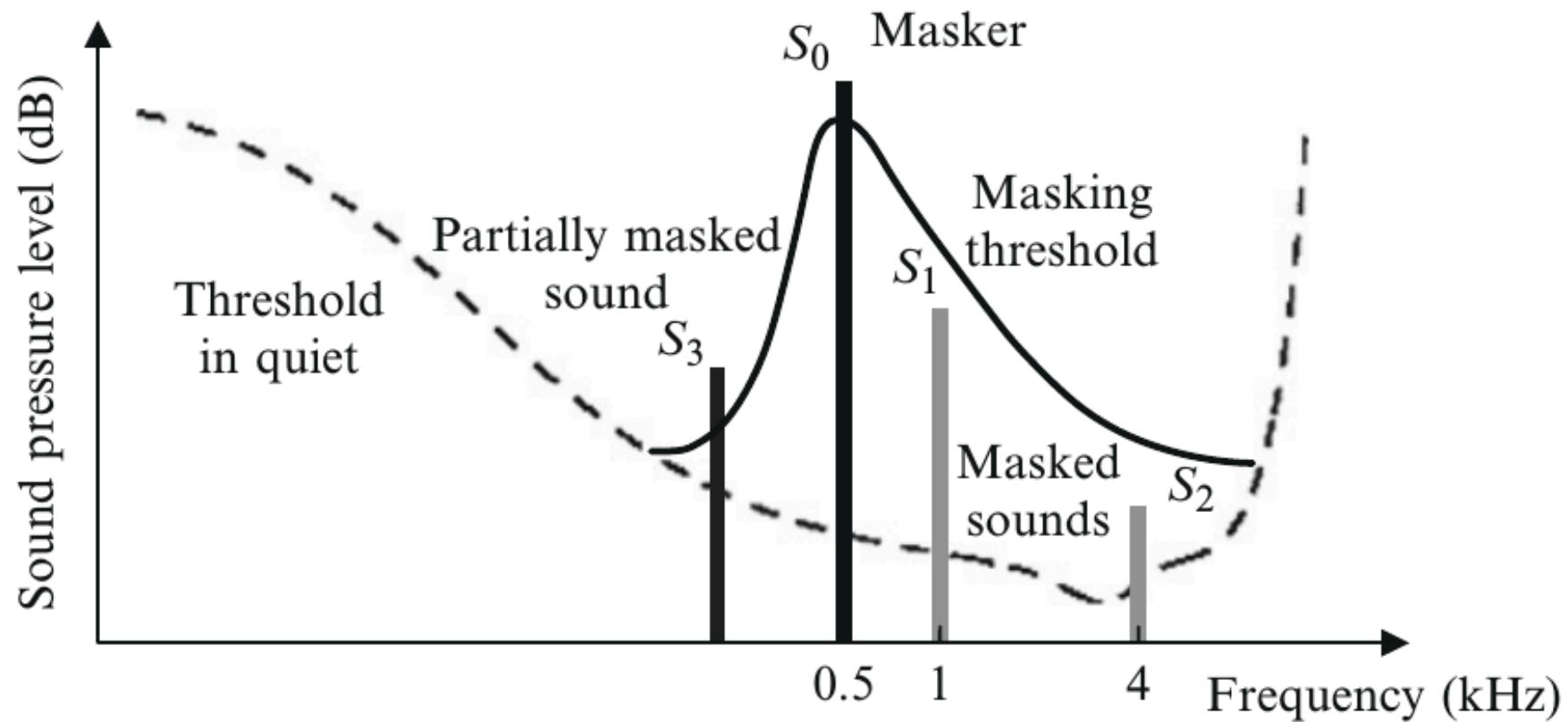
Audio Masking

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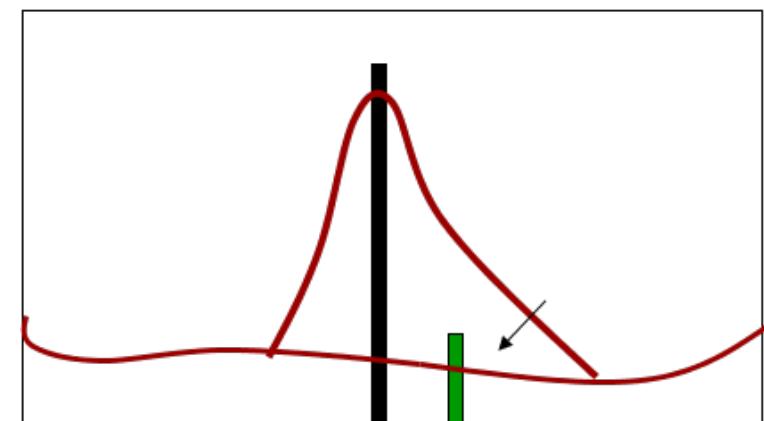
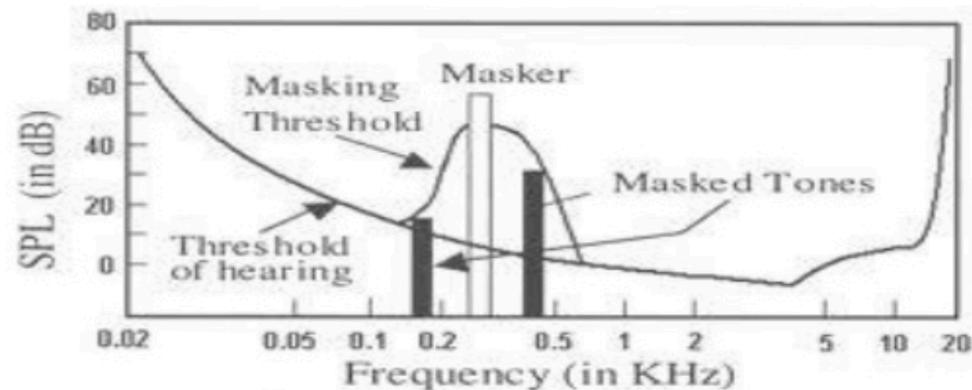
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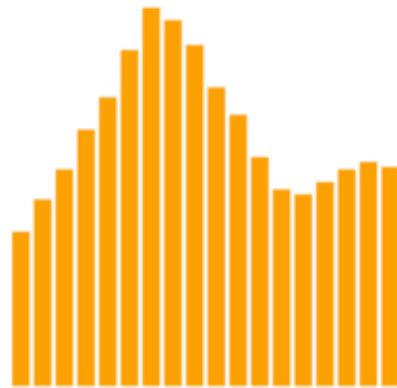


Audio Masking

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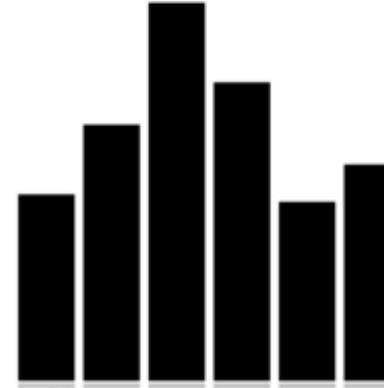
Audio Masking



WAV

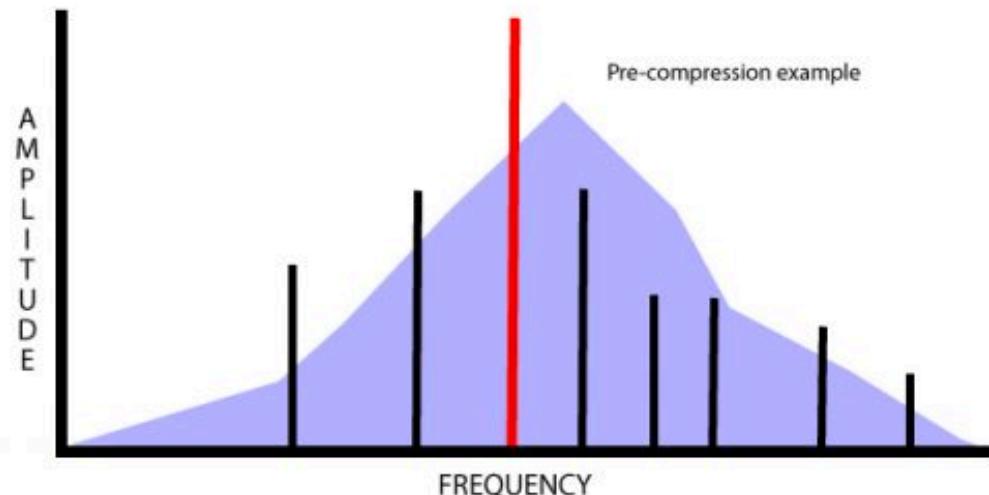
96kHz, 24bit 4096kbps

- VS -

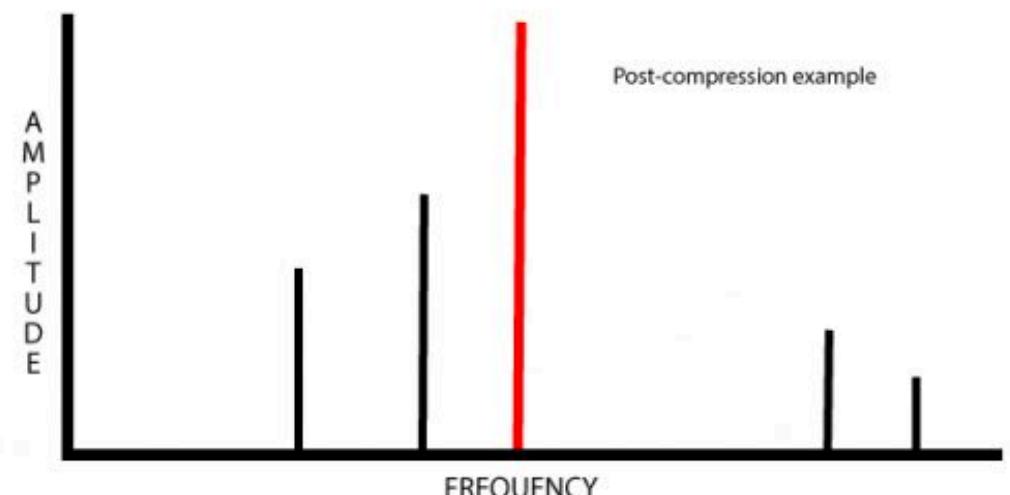


MP3

44kHz, 16bit 128kbps



Pre-compression example



Post-compression example

Audio Masking

