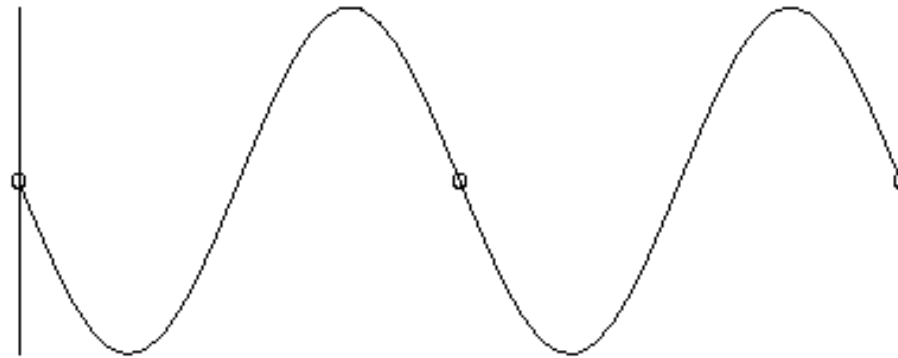


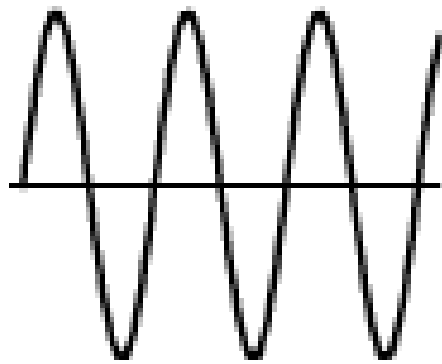
# Digital Sound



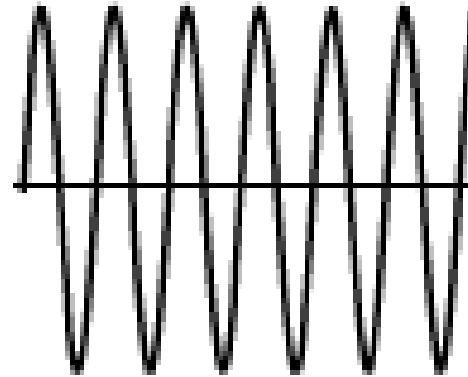
# Sine wave



Frequency = pitch

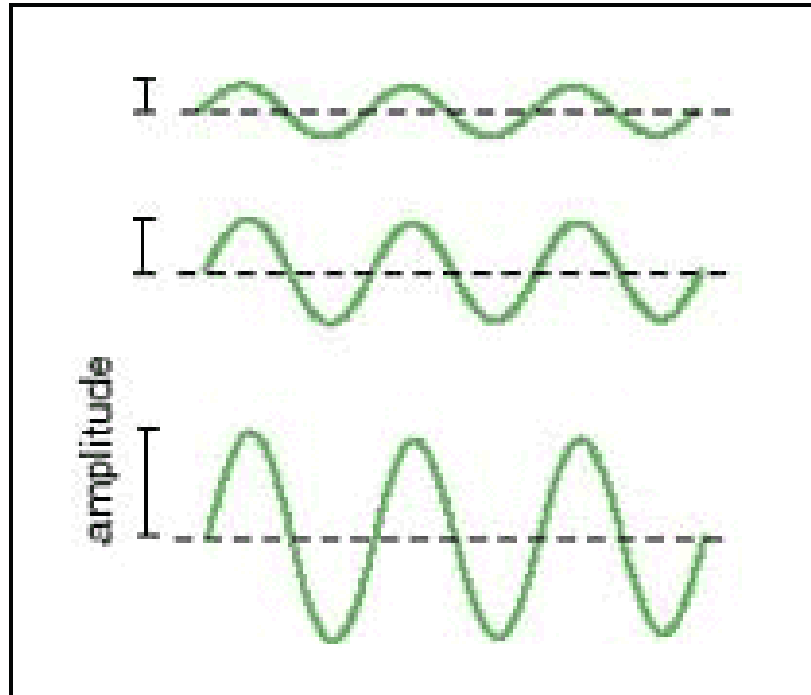


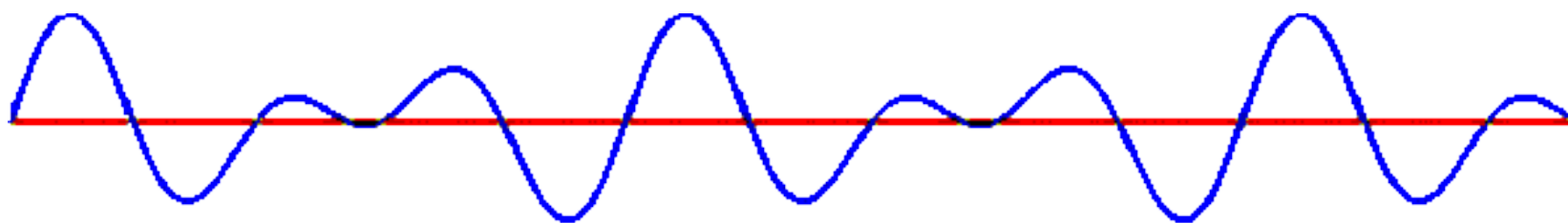
**Lower  
Pitch**



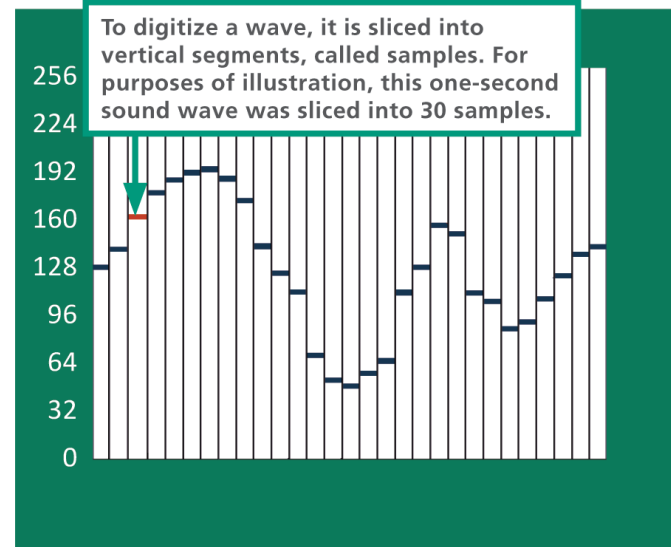
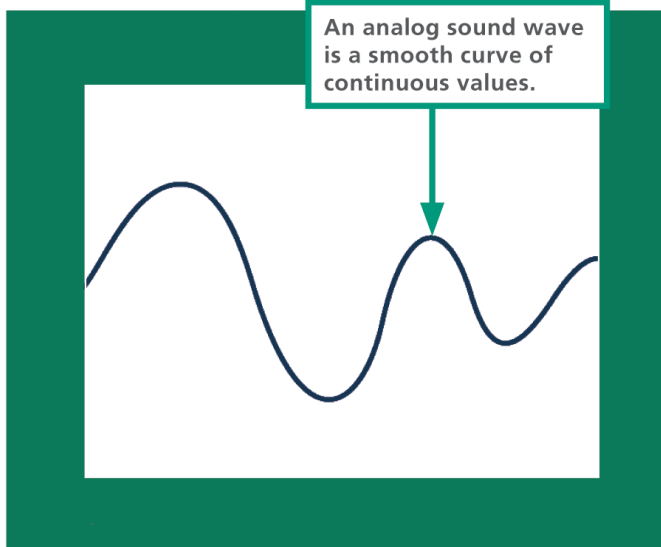
**Higher  
Pitch**

# Amplitude = volume





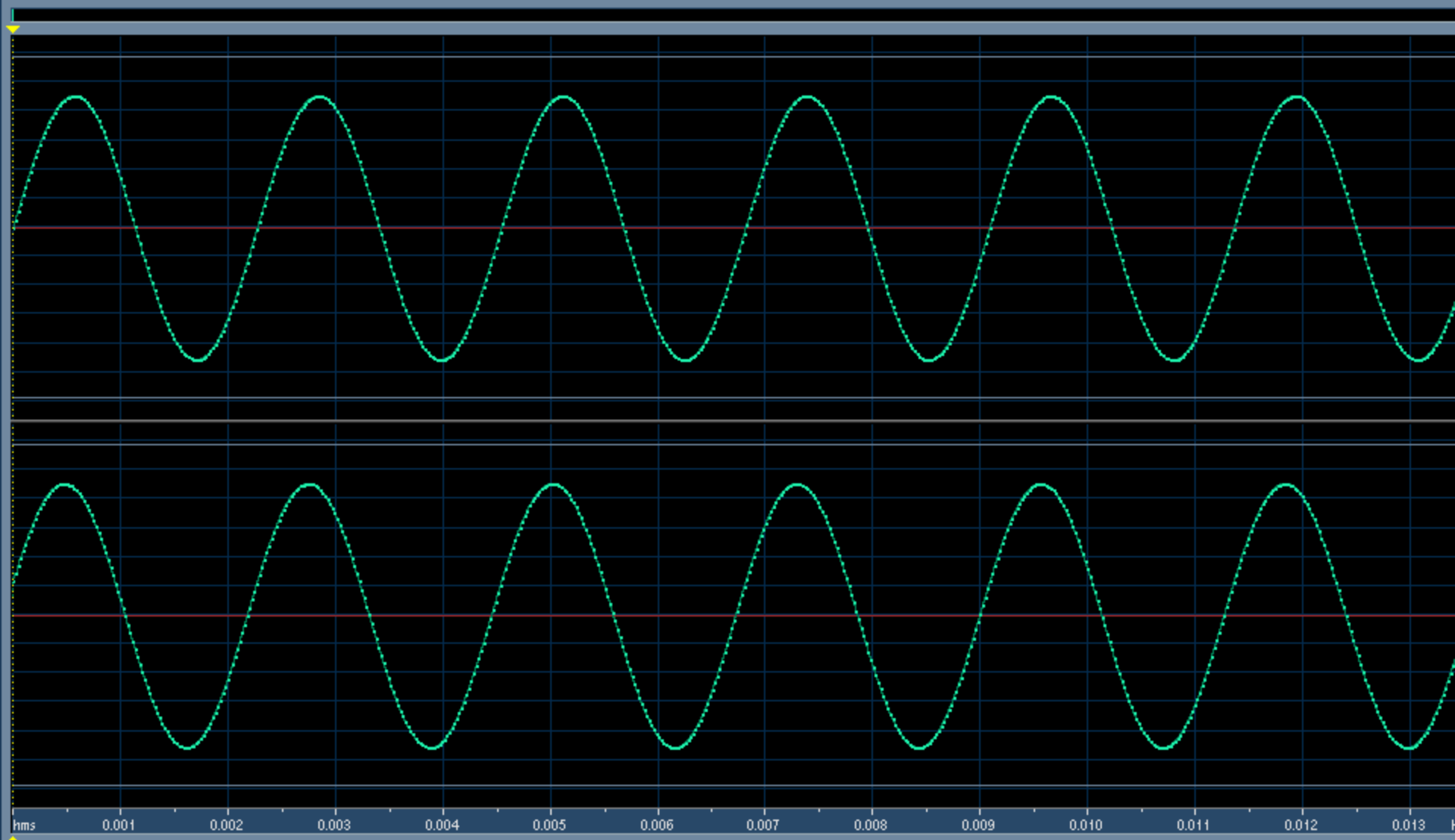
# Sampling



© Cengage Learning

SAMPLE	SAMPLE HEIGHT (DECIMAL)	SAMPLE HEIGHT (BINARY)
1	130	10000010
2	140	1000110
3	160	10100000
4	175	10101111

The height of each sample is converted into a binary number and stored. The height of sample 3 is 160 (decimal), so it is stored as its binary equivalent—10100000.

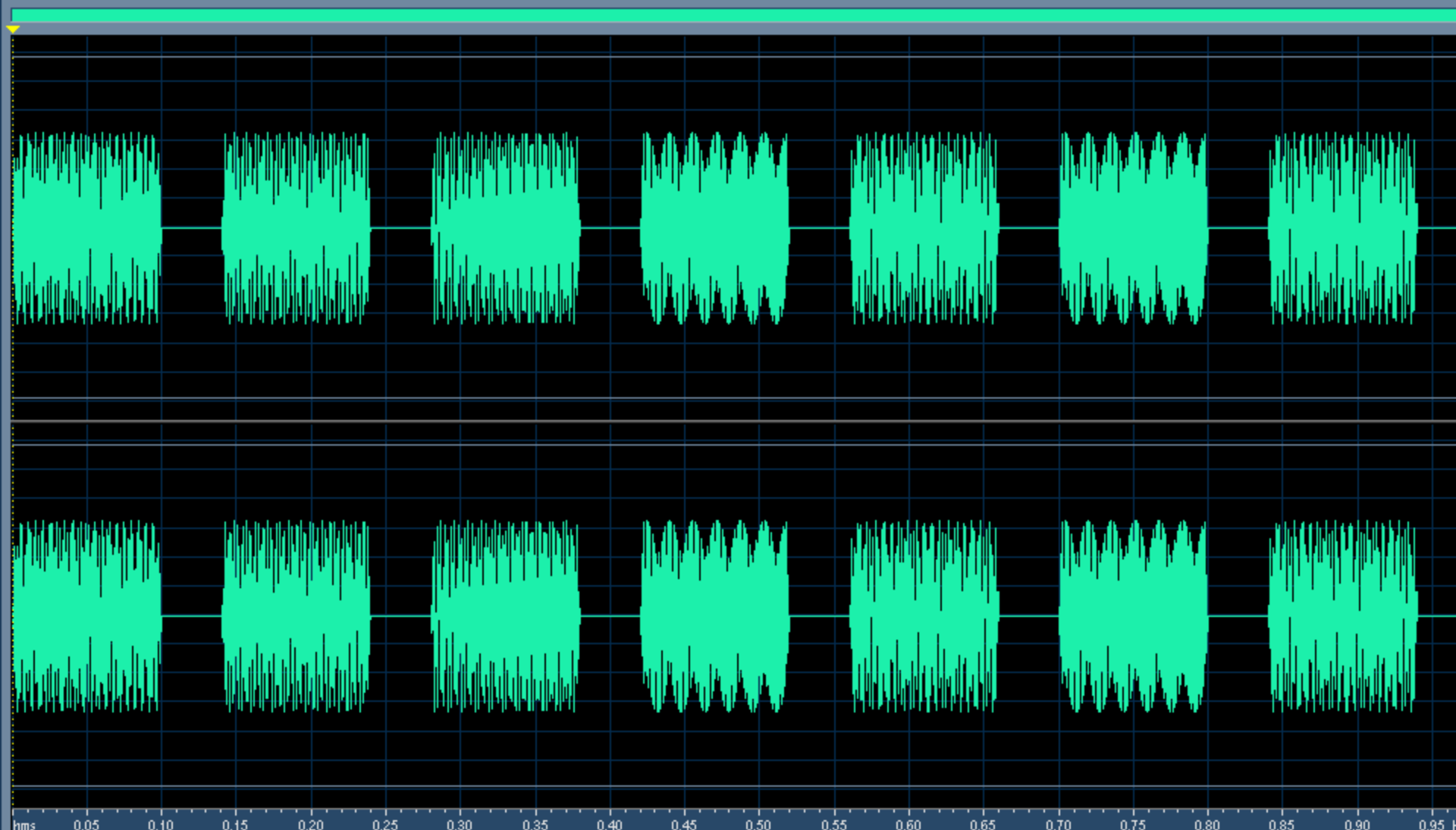


0:00.000



	Begin	End	Length
Sel	0:00.000		0:00.000
View	0:00.000	0:00.013	0:00.013





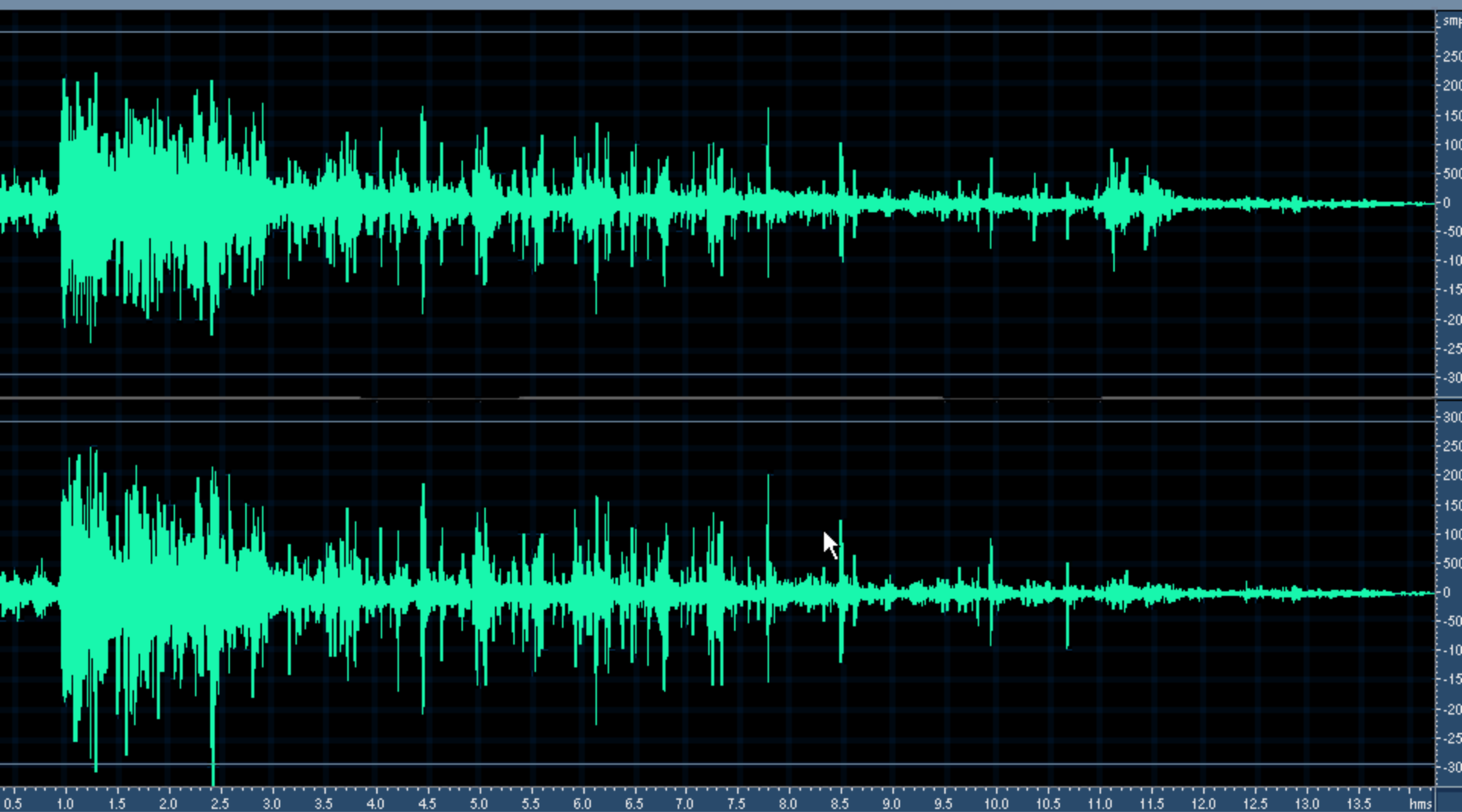
0:00.000



	Begin	End	Length
Sel	0:00.000		0:00.000
View	0:00.000	0:00.979	0:00.980

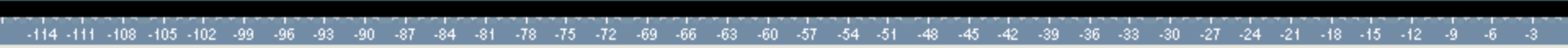


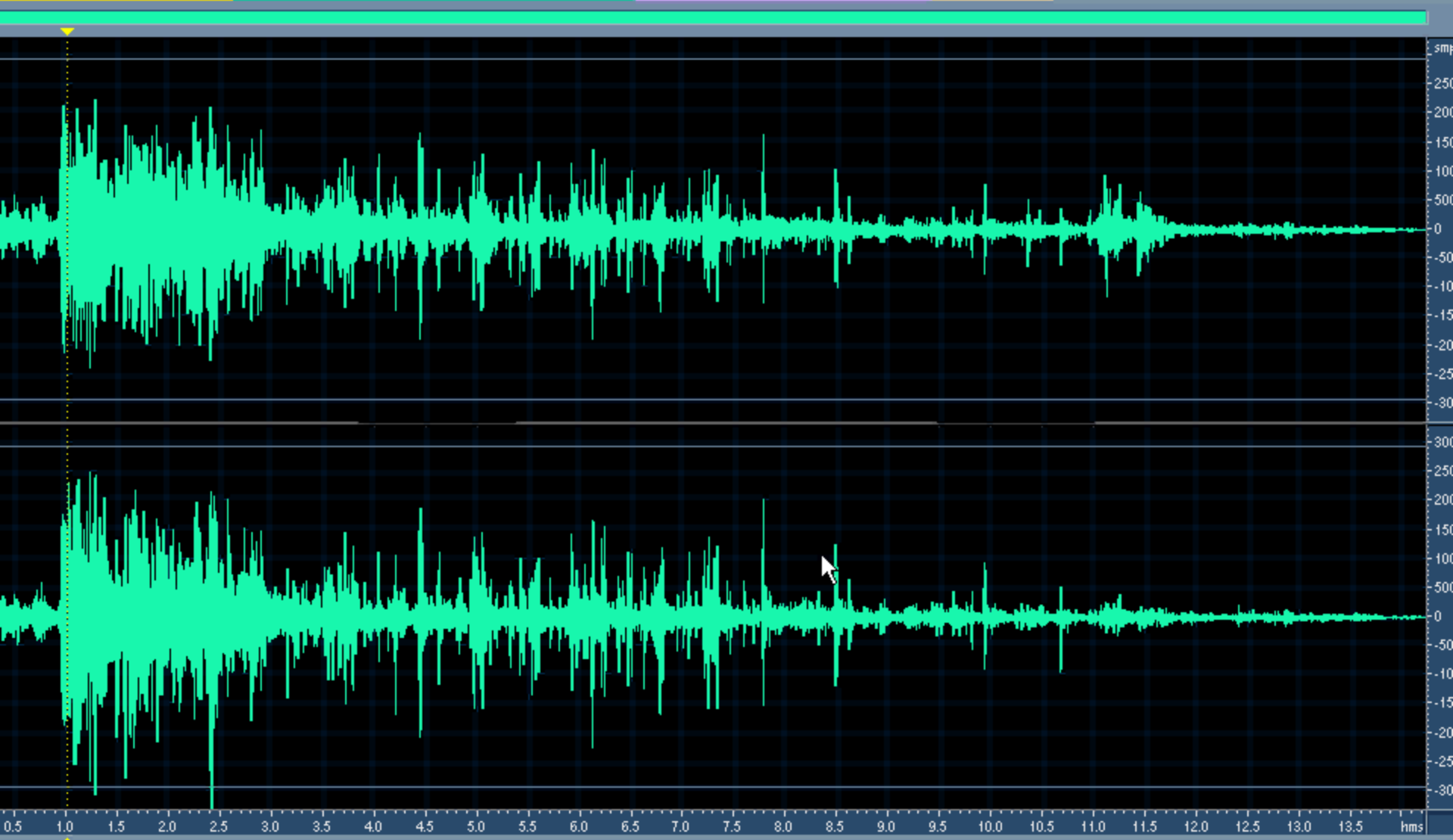




0:00.000

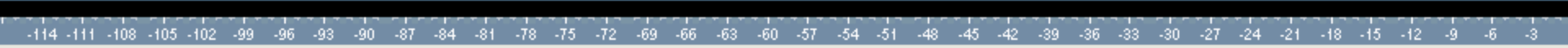
	Begin	End	Length
Sel	0:00.000		0:00.000
View	0:00.000	0:14.236	0:14.236





0:01.002

	Begin	End	Length
Sel	0:01.002		0:00.000
View	0:00.000	0:14.236	0:14.236



# Lots of data

- Higher sampling rate = better quality
- WAV file (compact disc quality)
- 44,100 samples per second
- 16 bits per sample
- Stereo (left and right channels)
- One second of sound = 1,411,200 bits
- One hour of sound = 5,080,320,000 bits

# Compression

- Using math to decrease the number of bits
- Three steps:
  - Analyze wave form
  - Look for patterns
  - Replace large patterns with smaller ones
- MP3 offers up to 11:1 compression ratio
- Advanced Audio Coding (AAC)
  - YouTube, iPhone, iPad, iTunes, etc.

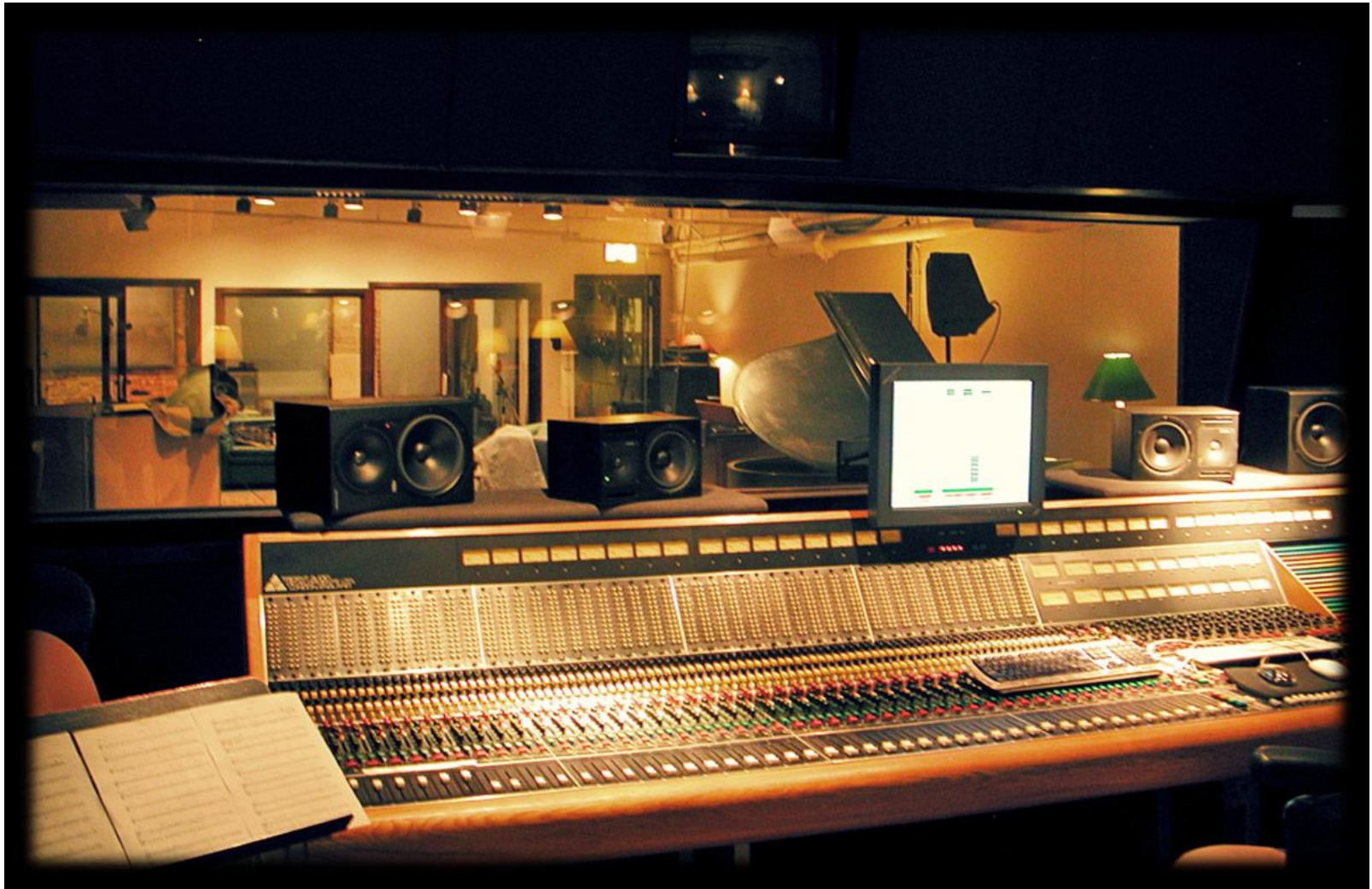
# Personal digital recording



# High-end personal digital recording



# Digital recording studio



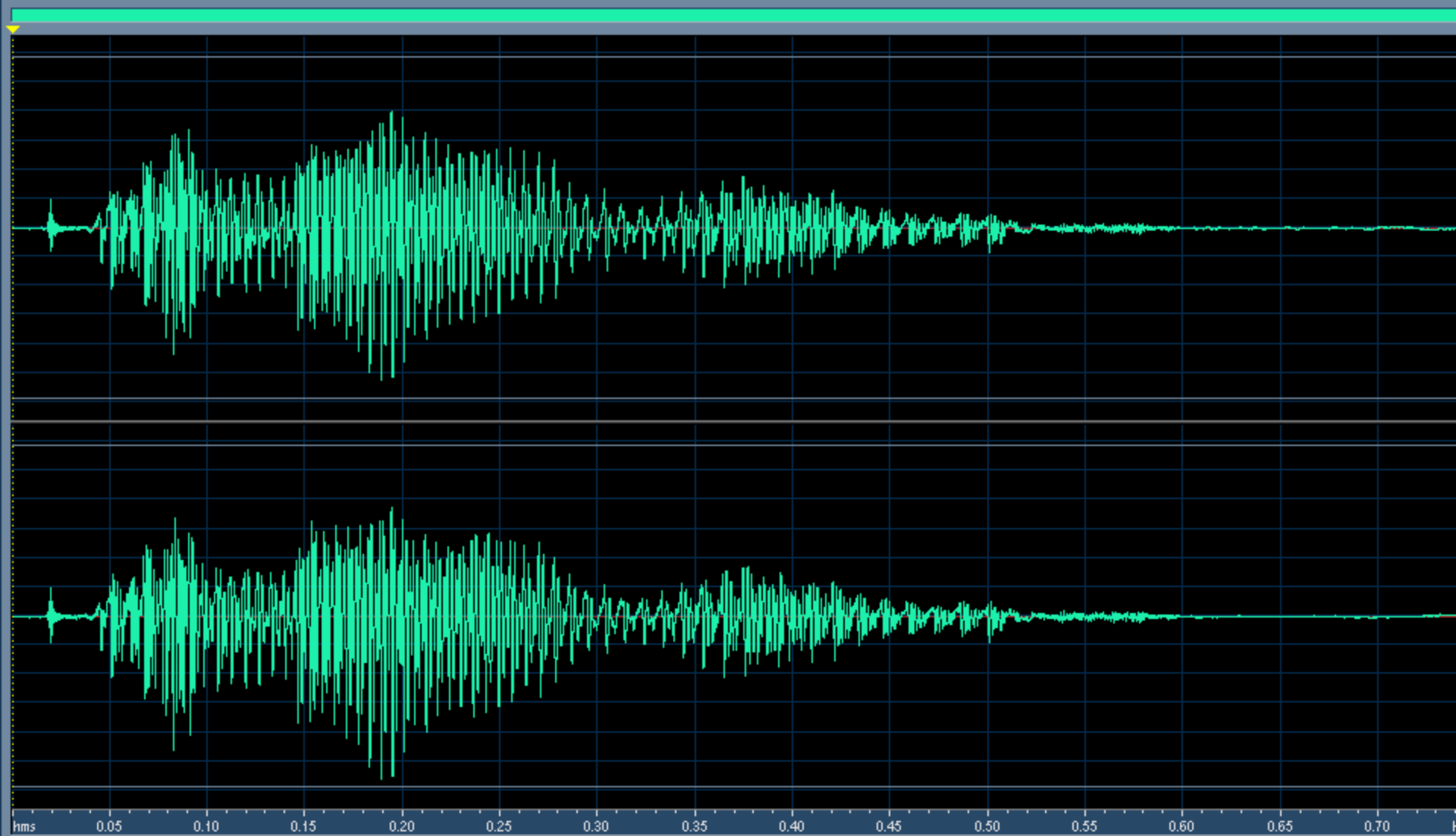
# Professional recording

- 44,100 / 16-bit
- 48,000 / 16-bit
- 96,000 / 24-bit
- 192,000 / 32-bit / surround sound
  
- In other words...

**LOTS OF DATA!**



# Signal Processing

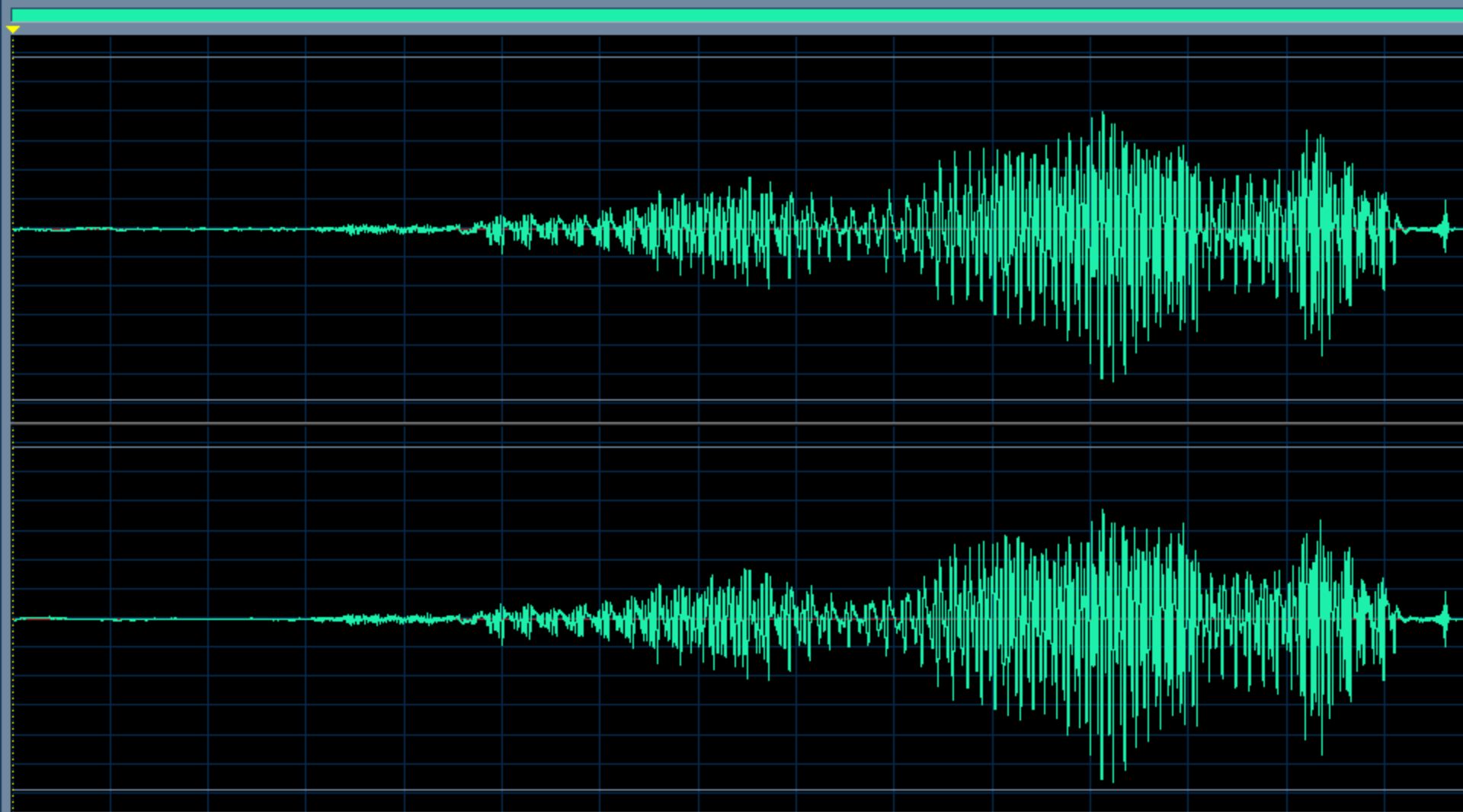


0:00.000



	Begin	End	Length
Sel	0:00.000		0:00.000
View	0:00.000	0:00.750	0:00.750





hms 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70



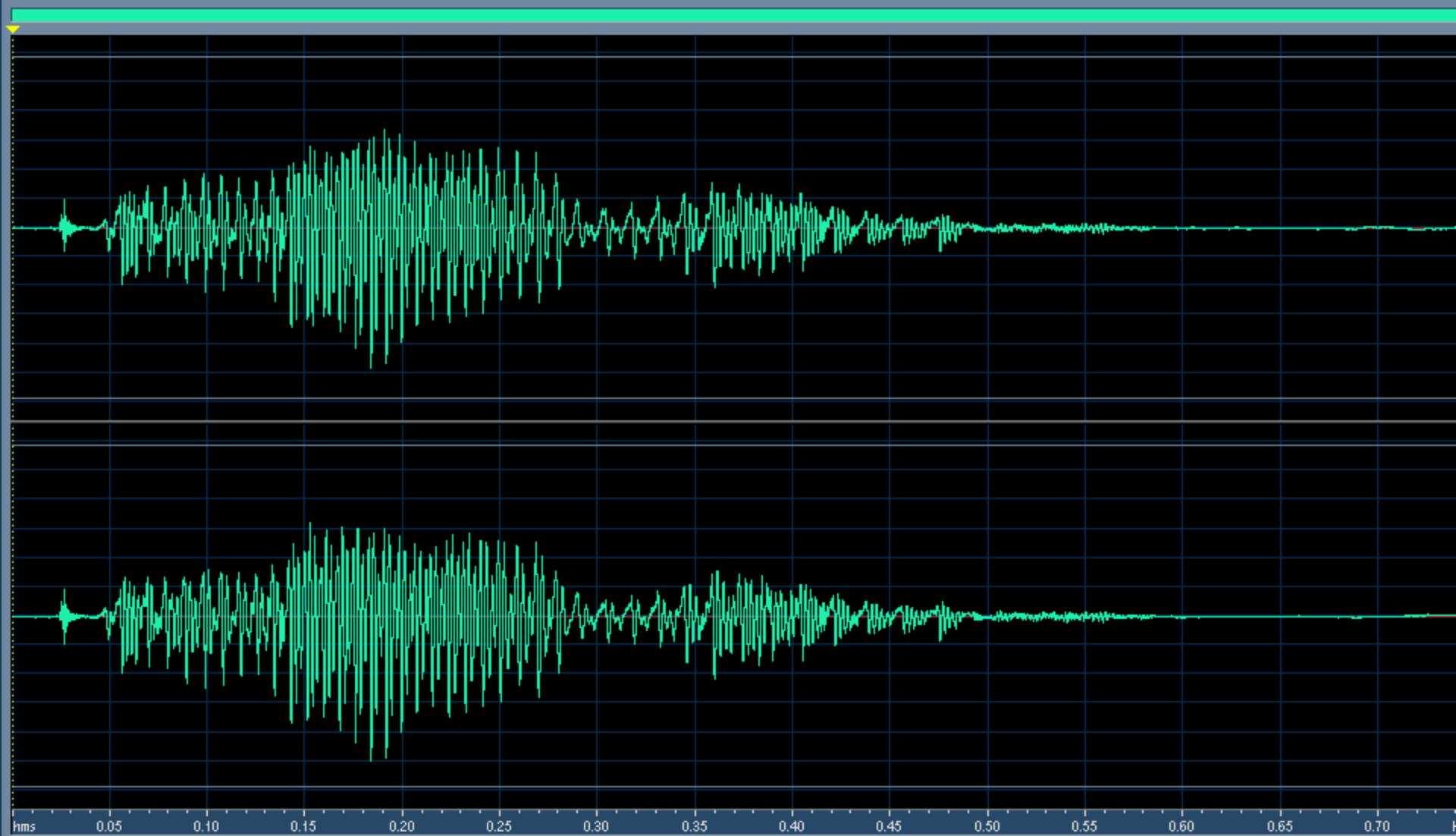
0:00.000



	Begin	End	Length
Sel	0:00.000		0:00.000
View	0:00.000	0:00.750	0:00.750

dB -114 -111 -108 -105 -102 -99 -96 -93 -90 -87 -84 -81 -78 -75 -72 -69 -66 -63 -60 -57 -54 -51 -48 -45 -42 -39 -36 -33 -30 -27 -24 -21 -18 -15 -12 -9 -6

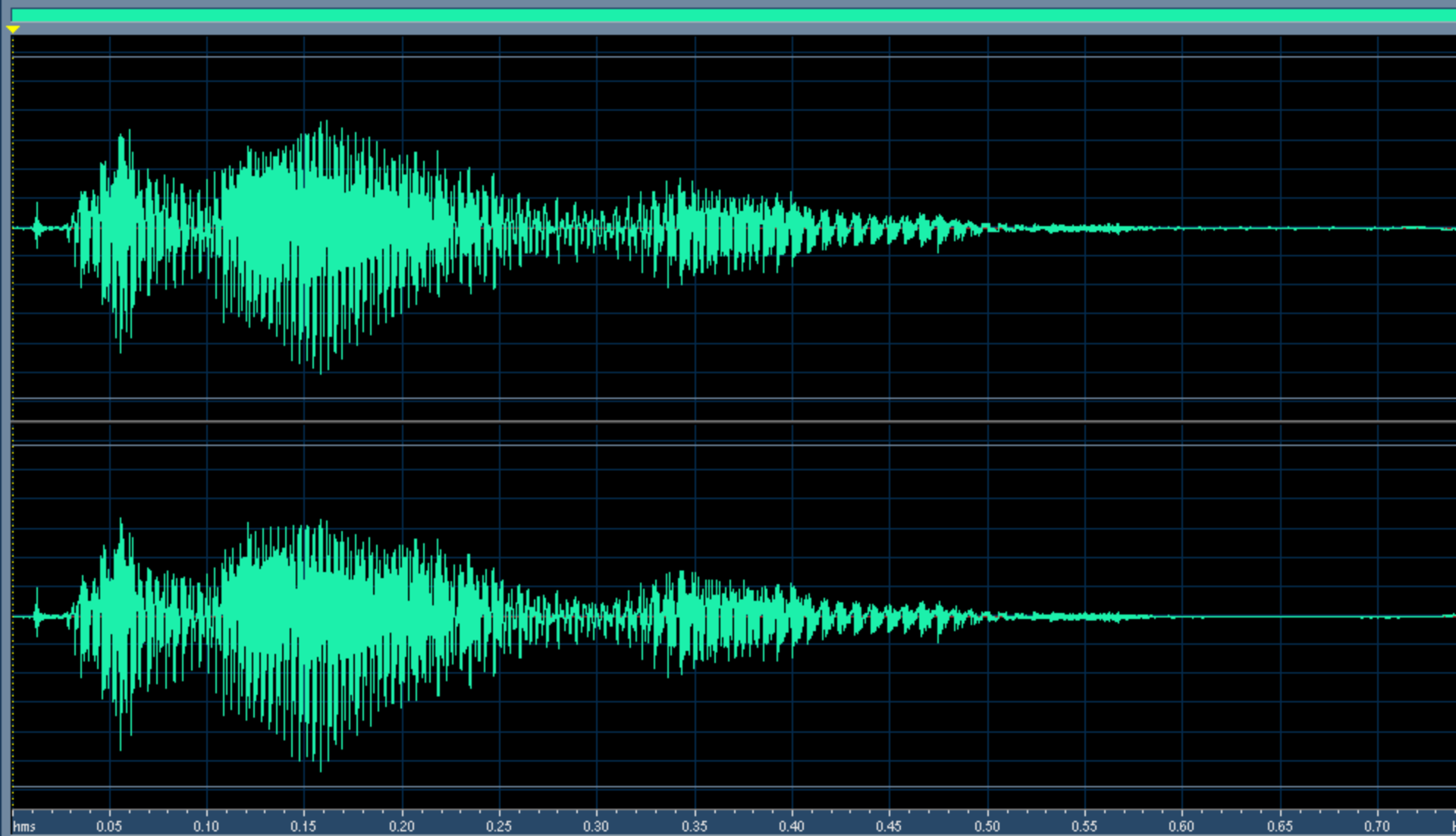
Zoom In Vertically [Ctrl+U]



0:00.000



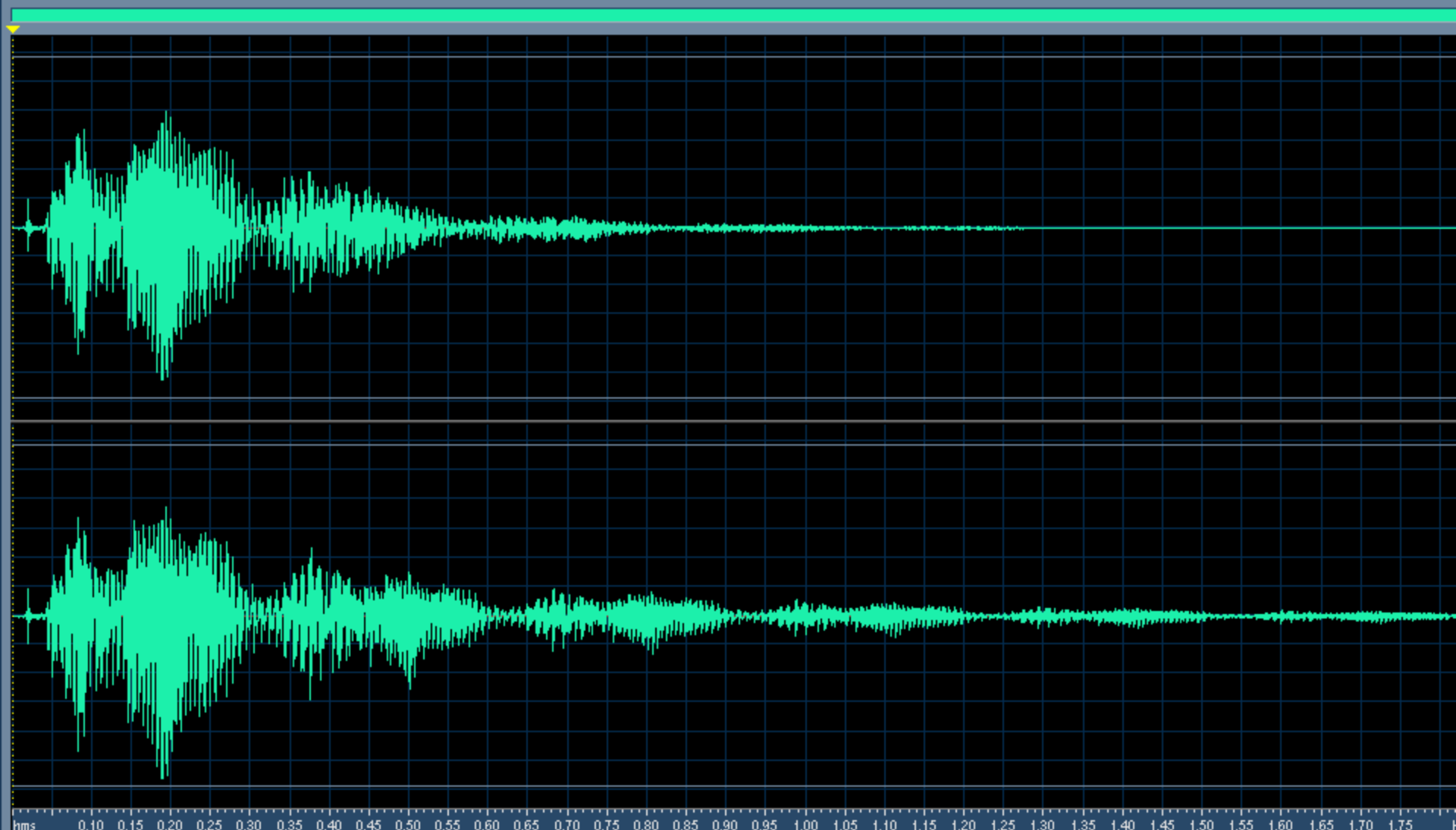
	Begin	End	Length
Sel	0:00.000		0:00.000
View	0:00.000	0:00.750	0:00.750



0:00.000

	Begin	End	Length
Sel	0:00.000		0:00.000
View	0:00.000	0:00.750	0:00.750



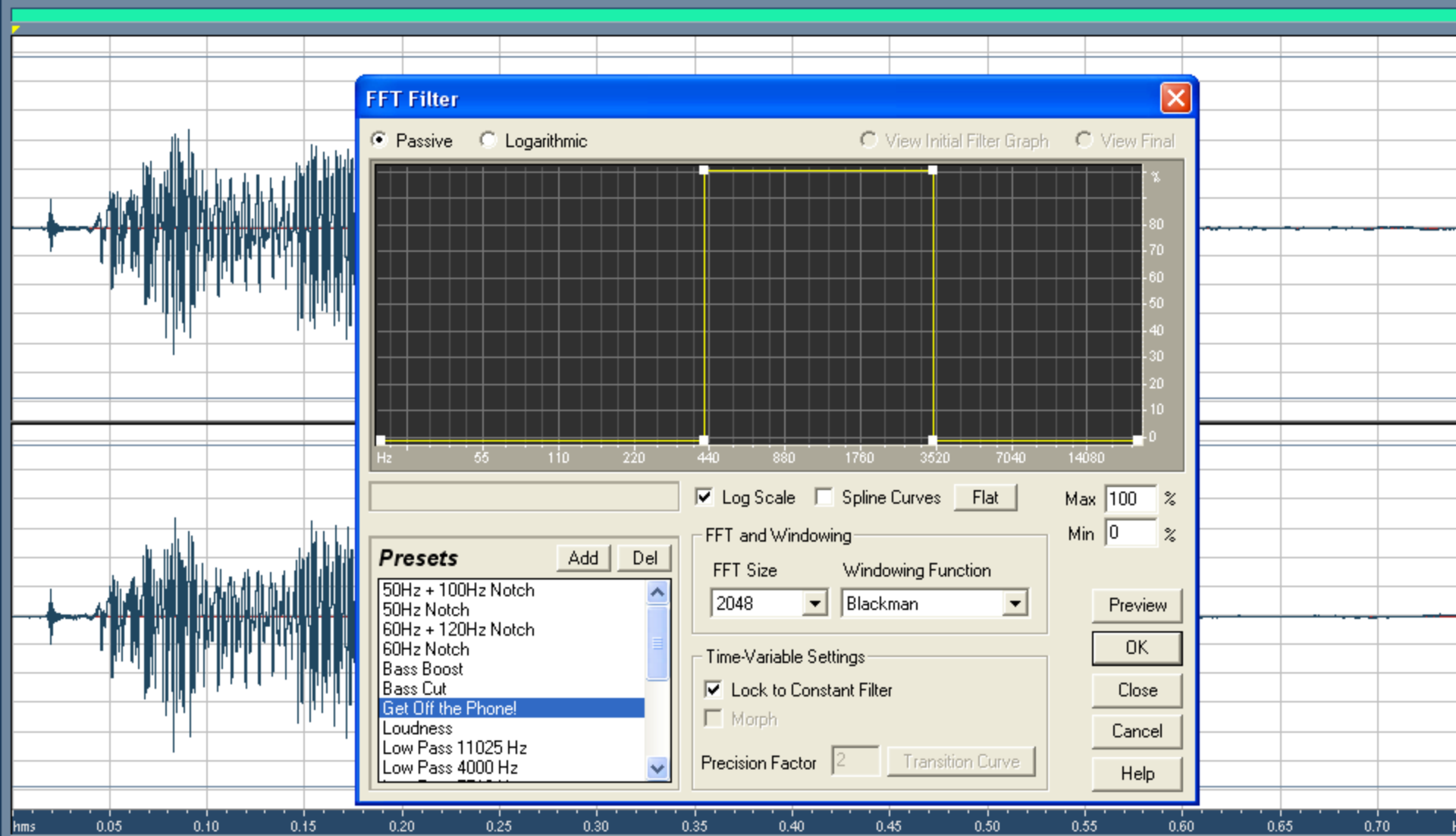


0:00.000



	Begin	End	Length
Sel	0:00.000		0:00.000
View	0:00.000	0:01.846	0:01.846





### FFT Filter

Passive     Logarithmic     View Initial Filter Graph     View Final

Hz: 55 110 220 440 880 1760 3520 7040 14080

Log Scale     Spline Curves    Flat    Max 100 %    Min 0 %

**Presets**    Add    Del

- 50Hz + 100Hz Notch
- 50Hz Notch
- 60Hz + 120Hz Notch
- 60Hz Notch
- Bass Boost
- Bass Cut
- Get Off the Phone!**
- Loudness
- Low Pass 11025 Hz
- Low Pass 4000 Hz

FFT and Windowing  
 FFT Size: 2048    Windowing Function: Blackman

Time-Variable Settings  
 Lock to Constant Filter     Morph

Precision Factor: 2    Transition Curve

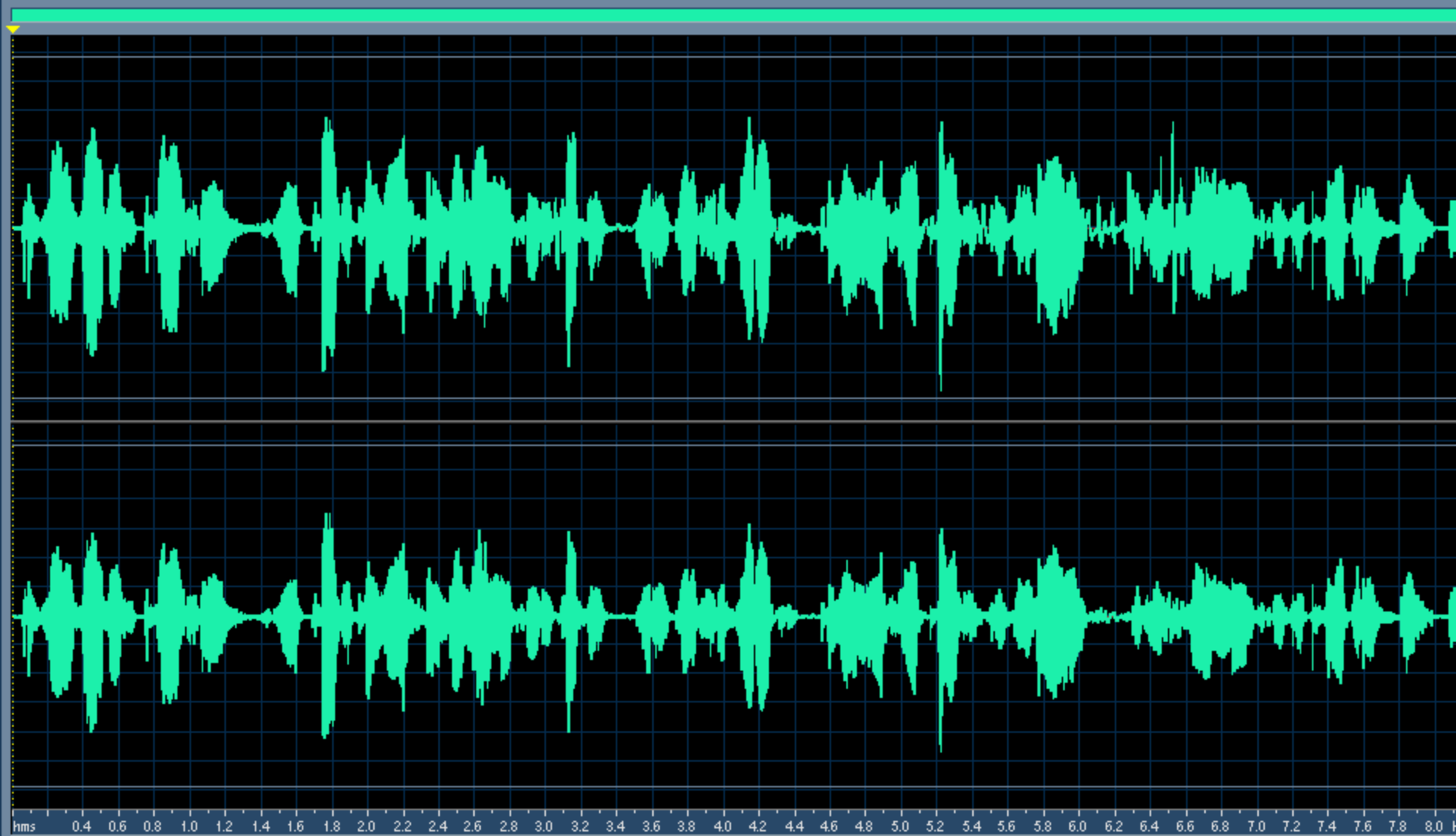
Preview    OK    Close    Cancel    Help



0:00.000



	Begin	End	Length
Sel	0:00.000	0:00.750	0:00.750
View	0:00.000	0:00.750	0:00.750



0:00.000



	Begin	End	Length
Sel	0:00.000		0:00.000
View	0:00.000	0:08.236	0:08.236





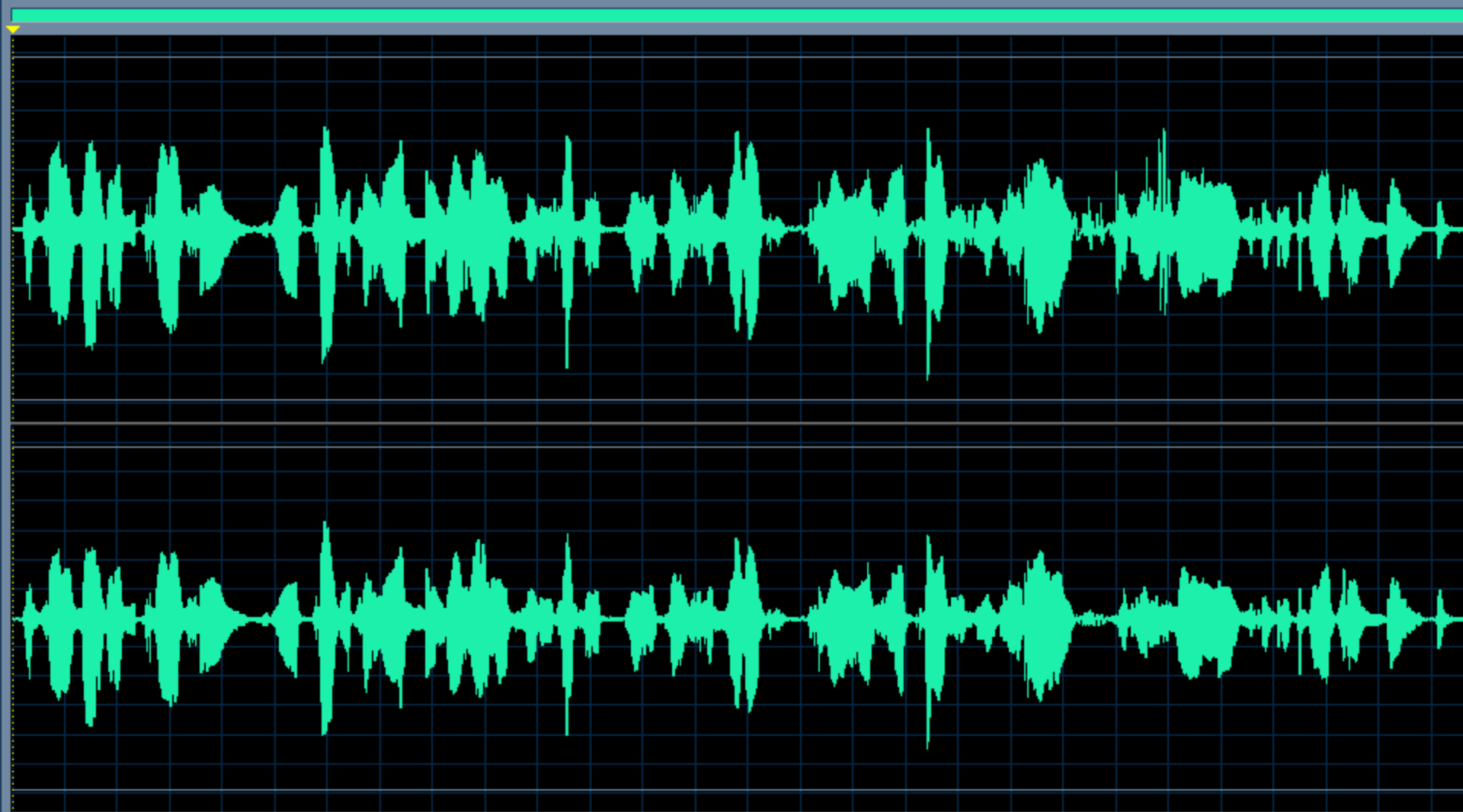


0:00.000



	Begin	End	Length
Sel	0:00.000		0:00.000
View	0:00.000	0:05.000	0:05.000





hms 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0 9.5 10.0 10.5 11.0 11.5 12.0 12.5 13.0 13.5

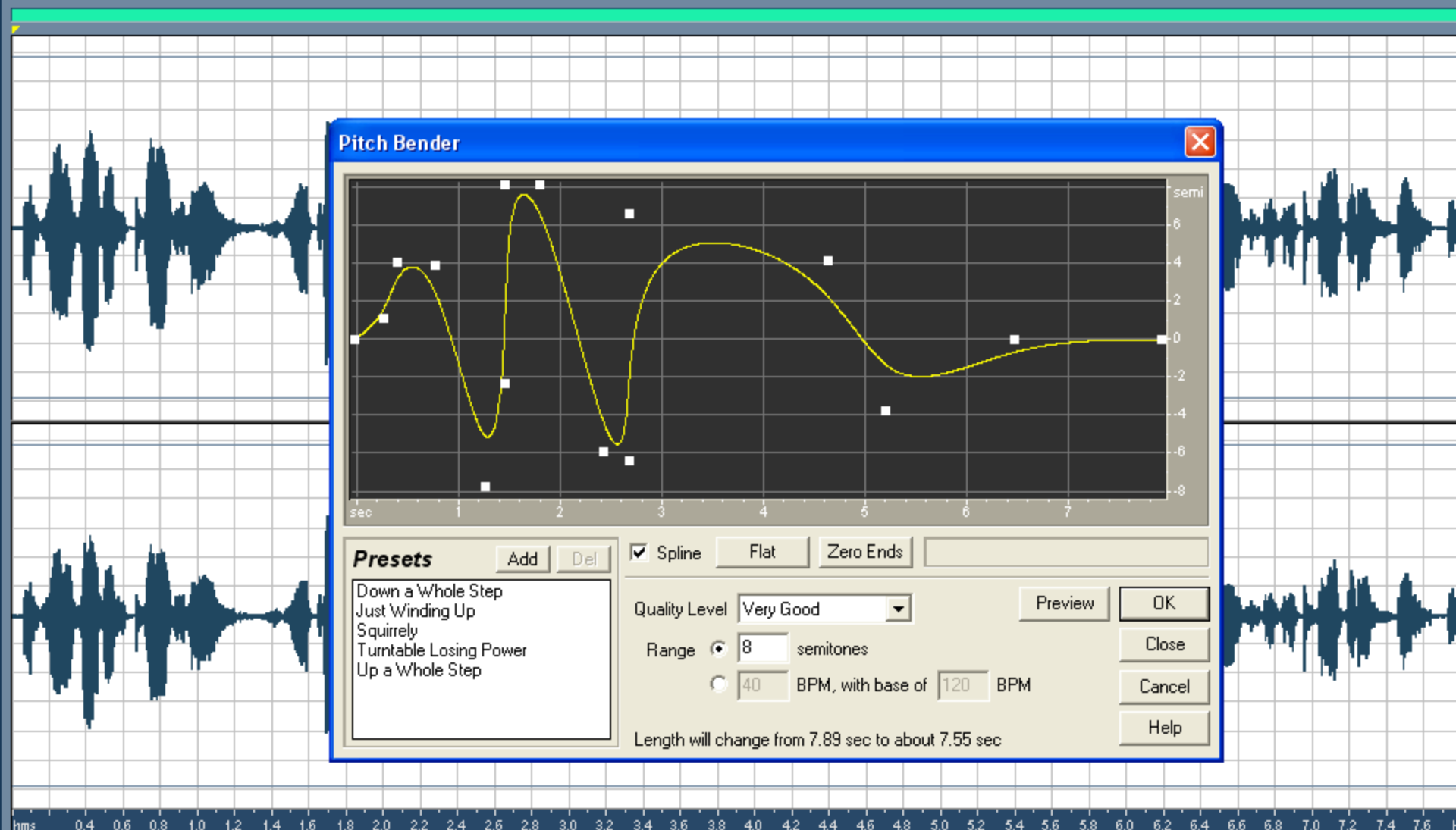


0:00.000



	Begin	End	Length
Sel	0:00.000		0:00.000
View	0:00.000	0:14.000	0:14.000

dB -114 -111 -108 -105 -102 -99 -96 -93 -90 -87 -84 -81 -78 -75 -72 -69 -66 -63 -60 -57 -54 -51 -48 -45 -42 -39 -36 -33 -30 -27 -24 -21 -18 -15 -12 -9 -6



### Pitch Bender

**Presets**    Add    Del

- Down a Whole Step
- Just Winding Up
- Squirrely
- Turntable Losing Power
- Up a Whole Step

Spline    Flat    Zero Ends

Quality Level: Very Good    Preview    OK

Range:  8 semitones     40 BPM, with base of 120 BPM

Length will change from 7.89 sec to about 7.55 sec

Close    Cancel    Help

hms 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0 4.2 4.4 4.6 4.8 5.0 5.2 5.4 5.6 5.8 6.0 6.2 6.4 6.6 6.8 7.0 7.2 7.4 7.6

0:00.000

	Begin	End	Length
Sel	0:00.000	0:07.886	0:07.886
View	0:00.000	0:07.886	0:07.886

dB -114 -111 -108 -105 -102 -99 -96 -93 -90 -87 -84 -81 -78 -75 -72 -69 -66 -63 -60 -57 -54 -51 -48 -45 -42 -39 -36 -33 -30 -27 -24 -21 -18 -15 -12 -9 -6

# **Multi-track recording and editing**



0:00.000

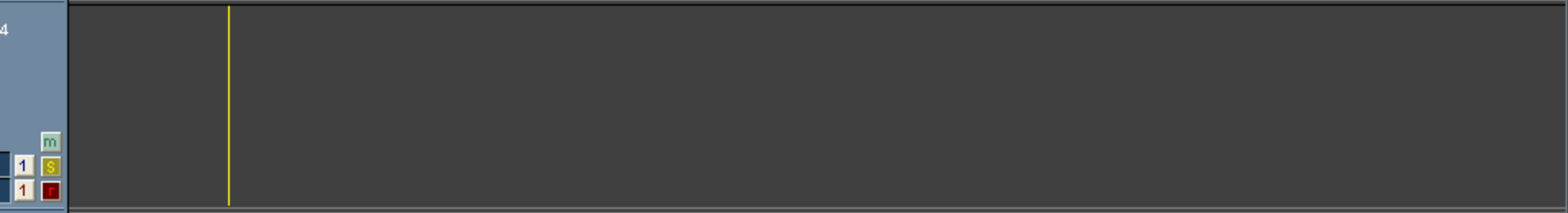
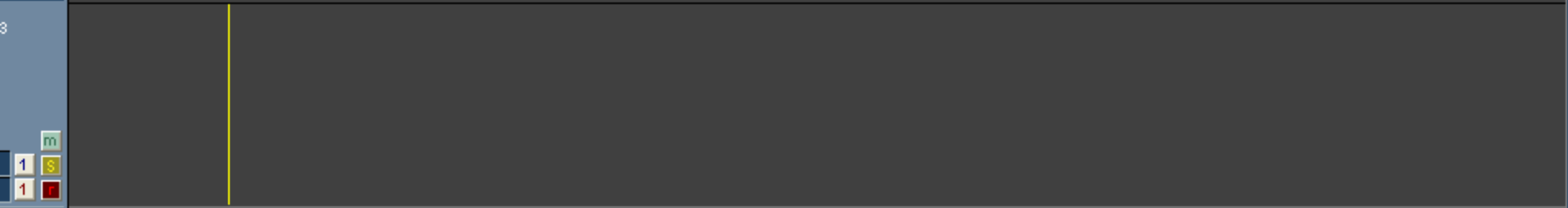
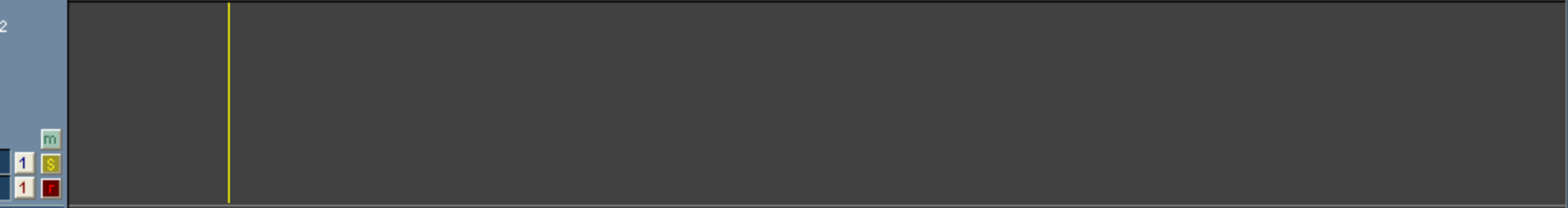


	Begin	End	Length
Sel	0:00.000		0:00.000
View	0:00.000	0:26.913	0:26.913





r: 0.0



hms 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0 30.0 32.0 34.0 36.0 hms



0:04.074

	Begin	End	Length
Sel	0:04.074		0:00.000
View	0:00.000	0:38.405	0:38.405

-114 -111 -108 -105 -102 -99 -96 -93 -90 -87 -84 -81 -78 -75 -72 -69 -66 -63 -60 -57 -54 -51 -48 -45 -42 -39 -36 -33 -30 -27 -24 -21 -18 -15 -12 -9 -6 -3



Master: 0.0

Track 1

Weather - voice only



Track 2

thunder



Track 3

Track 4

hms 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0 30.0 32.0 34.0 36.0



0:08.736



	Begin	End	Length
Sel	0:08.736		0:00.00
View	0:00.000	0:38.405	0:38.40

dB -114 -111 -108 -105 -102 -99 -96 -93 -90 -87 -84 -81 -78 -75 -72 -69 -66 -63 -60 -57 -54 -51 -48 -45 -42 -39 -36 -33 -30 -27 -24 -21 -18 -15 -12 -9 -6



Master: 0.0

Track 1

Weather - voice only

P +0

V 0.0

Track 2

thunder

P +0

V 0.0

Track 3

rain

P +0

V 0.0

Track 4

P +0

V 0.0

hms 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0 30.0 32.0 34.0 36.0



0:12.998



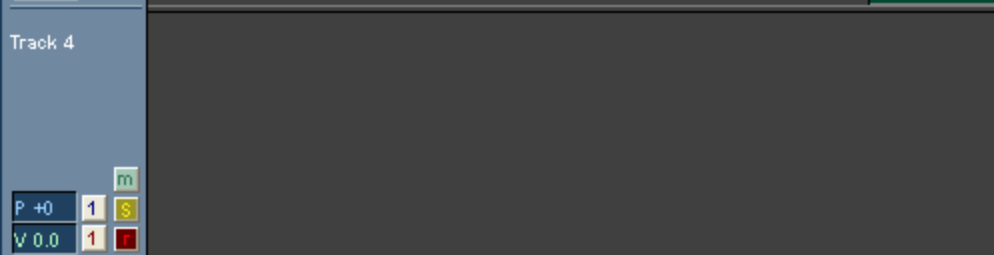
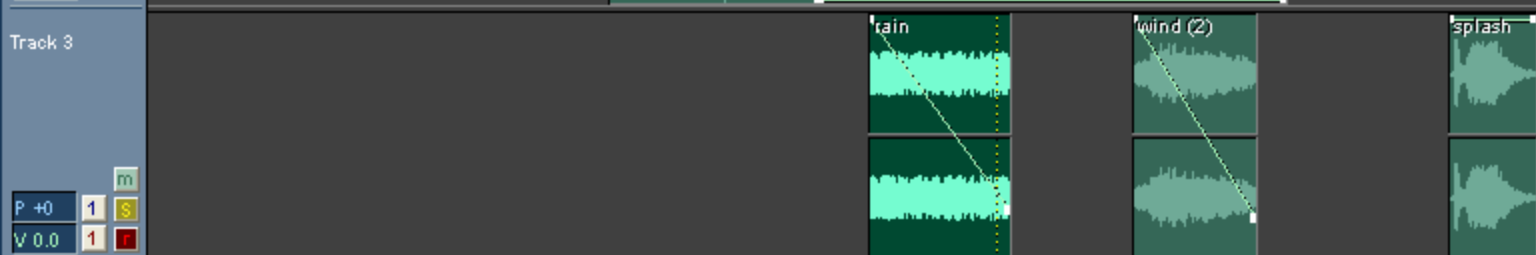
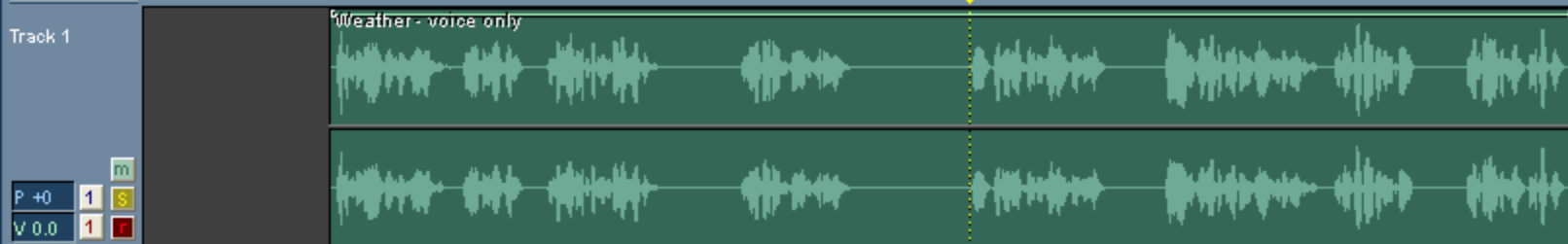
	Begin	End	Length
Sel	0:12.998		0:00.00
View	0:00.000	0:38.405	0:38.40

dB -114 -111 -108 -105 -102 -99 -96 -93 -90 -87 -84 -81 -78 -75 -72 -69 -66 -63 -60 -57 -54 -51 -48 -45 -42 -39 -36 -33 -30 -27 -24 -21 -18 -15 -12 -9 -6





Master: 0.0



hms 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0 30.0 32.0 34.0 36.0

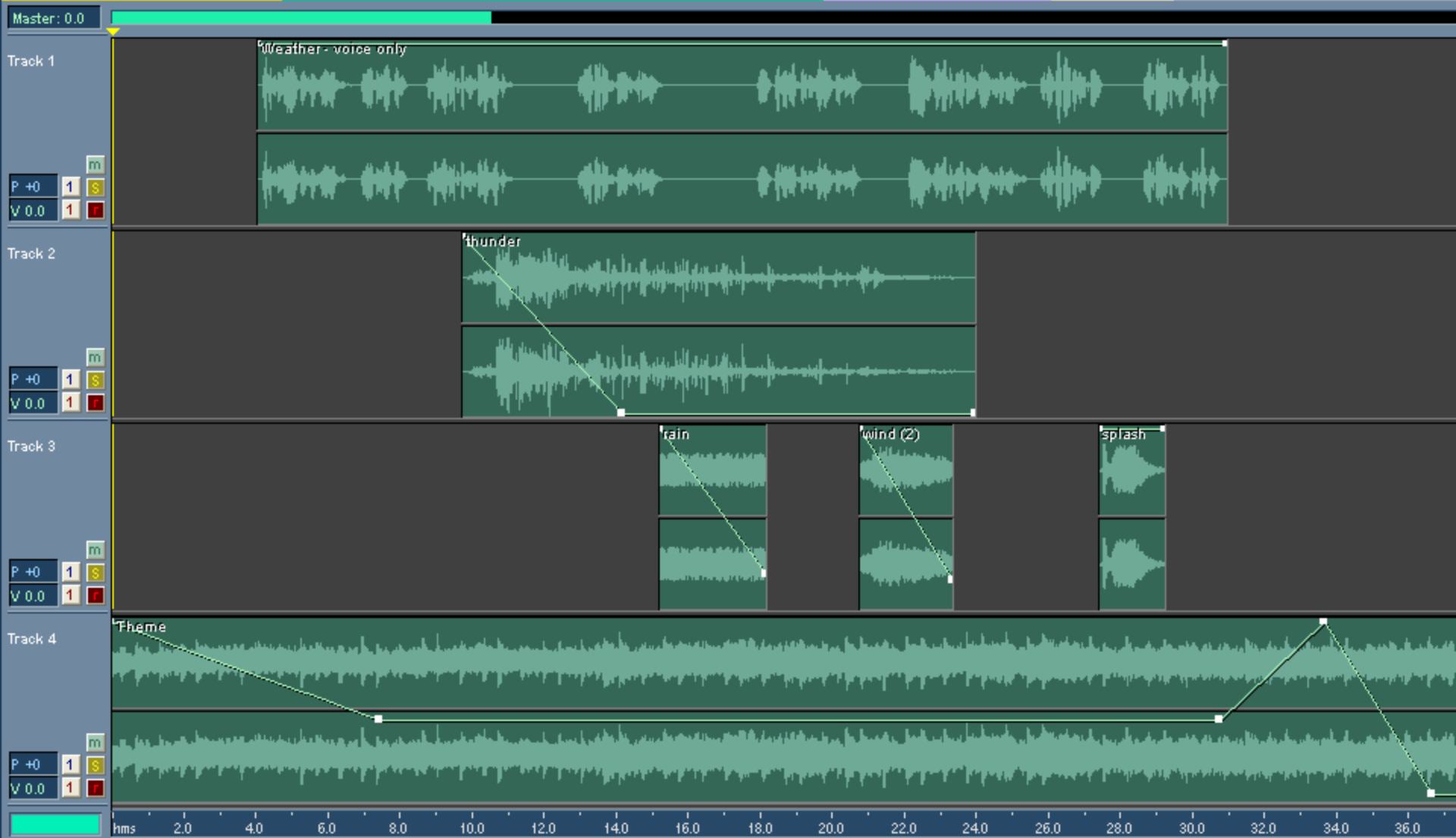


0:17.894



	Begin	End	Length
Sel	0:17.894		0:00.00
View	0:00.000	0:38.405	0:38.40

dB -114 -111 -108 -105 -102 -99 -96 -93 -90 -87 -84 -81 -78 -75 -72 -69 -66 -63 -60 -57 -54 -51 -48 -45 -42 -39 -36 -33 -30 -27 -24 -21 -18 -15 -12 -9 -6



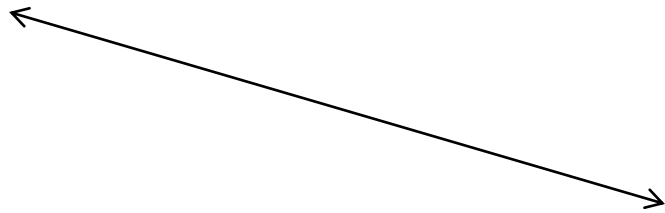
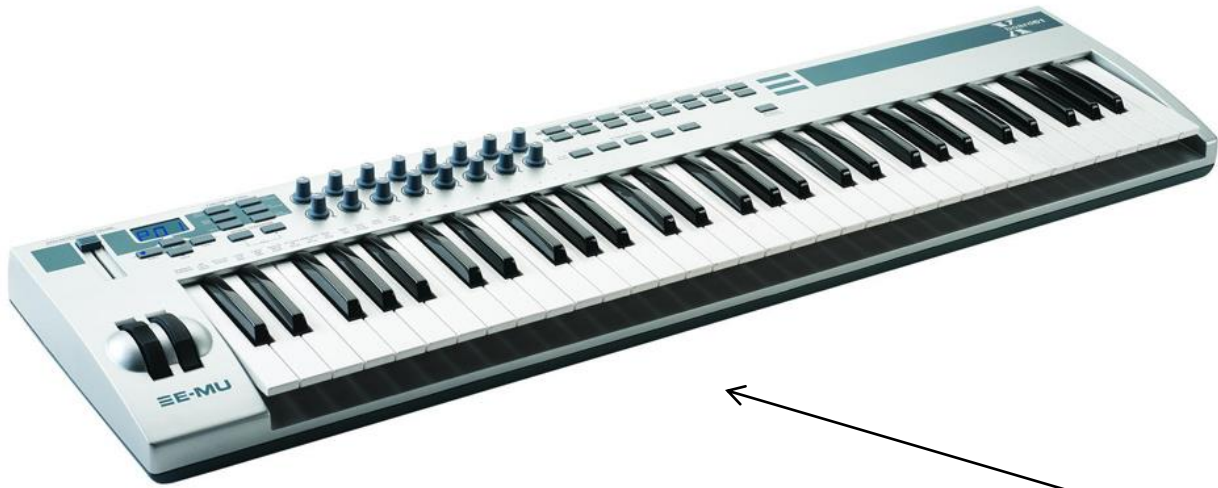
0:38.404



	Begin	End	Length
Sel	0:00.000		0:00.00
View	0:00.000	0:38.405	0:38.40



# **Musical Instrument Digital Interface (MIDI)**



# Small amount of data

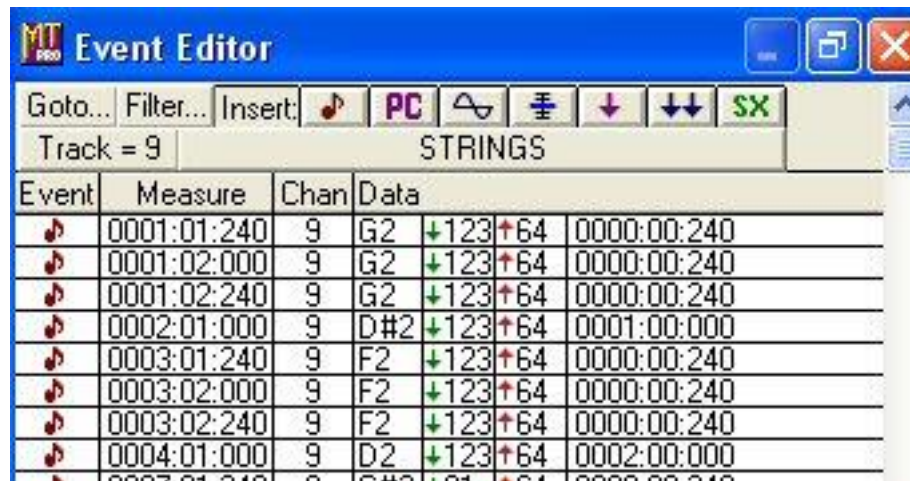
- One “event” = 16 bits
- An event is:
  - Start of a musical note
  - End of a musical note
  - Special commands
    - Play loud
    - Play soft
    - Etc.

The image displays a musical score in a software interface. The score consists of four staves, all in a 2/4 time signature and the key of B-flat major (two flats). The notation is as follows:







- Staff 1 (Treble Clef):** Measure 1: quarter rest, quarter note B-flat, quarter note C, quarter note D. Measure 2: quarter rest, quarter note B-flat, quarter note C, quarter note D. Measure 3: quarter rest, quarter note B-flat, quarter note C, quarter note D. Measure 4: quarter note B-flat, quarter note C, quarter note D, quarter note E. Measure 5: quarter note B-flat, quarter note C, quarter note D, quarter note E. Measure 6: quarter note B-flat, quarter note C, quarter note D, quarter note E.
- Staff 2 (Bass Clef):** Measure 1: quarter rest, quarter note B-flat, quarter note C, quarter note D. Measure 2: quarter rest, quarter note B-flat, quarter note C, quarter note D. Measure 3: quarter rest, quarter note B-flat, quarter note C, quarter note D. Measure 4: quarter note B-flat, quarter note C, quarter note D, quarter note E. Measure 5: quarter note B-flat, quarter note C, quarter note D, quarter note E. Measure 6: quarter note B-flat, quarter note C, quarter note D, quarter note E.
- Staff 3 (Bass Clef):** Measure 1: quarter rest, quarter note B-flat, quarter note C, quarter note D. Measure 2: quarter rest, quarter note B-flat, quarter note C, quarter note D. Measure 3: quarter rest, quarter note B-flat, quarter note C, quarter note D. Measure 4: quarter note B-flat, quarter note C, quarter note D, quarter note E. Measure 5: quarter note B-flat, quarter note C, quarter note D, quarter note E. Measure 6: quarter note B-flat, quarter note C, quarter note D, quarter note E.
- Staff 4 (Bass Clef):** Measure 1: quarter rest, quarter note B-flat, quarter note C, quarter note D. Measure 2: quarter rest, quarter note B-flat, quarter note C, quarter note D. Measure 3: quarter rest, quarter note B-flat, quarter note C, quarter note D. Measure 4: quarter note B-flat, quarter note C, quarter note D, quarter note E. Measure 5: quarter note B-flat, quarter note C, quarter note D, quarter note E. Measure 6: quarter note B-flat, quarter note C, quarter note D, quarter note E.

There are ties between the notes in measures 4 and 5 across all four staves. A mouse cursor is visible in the lower right area of the score.









# MIDI events



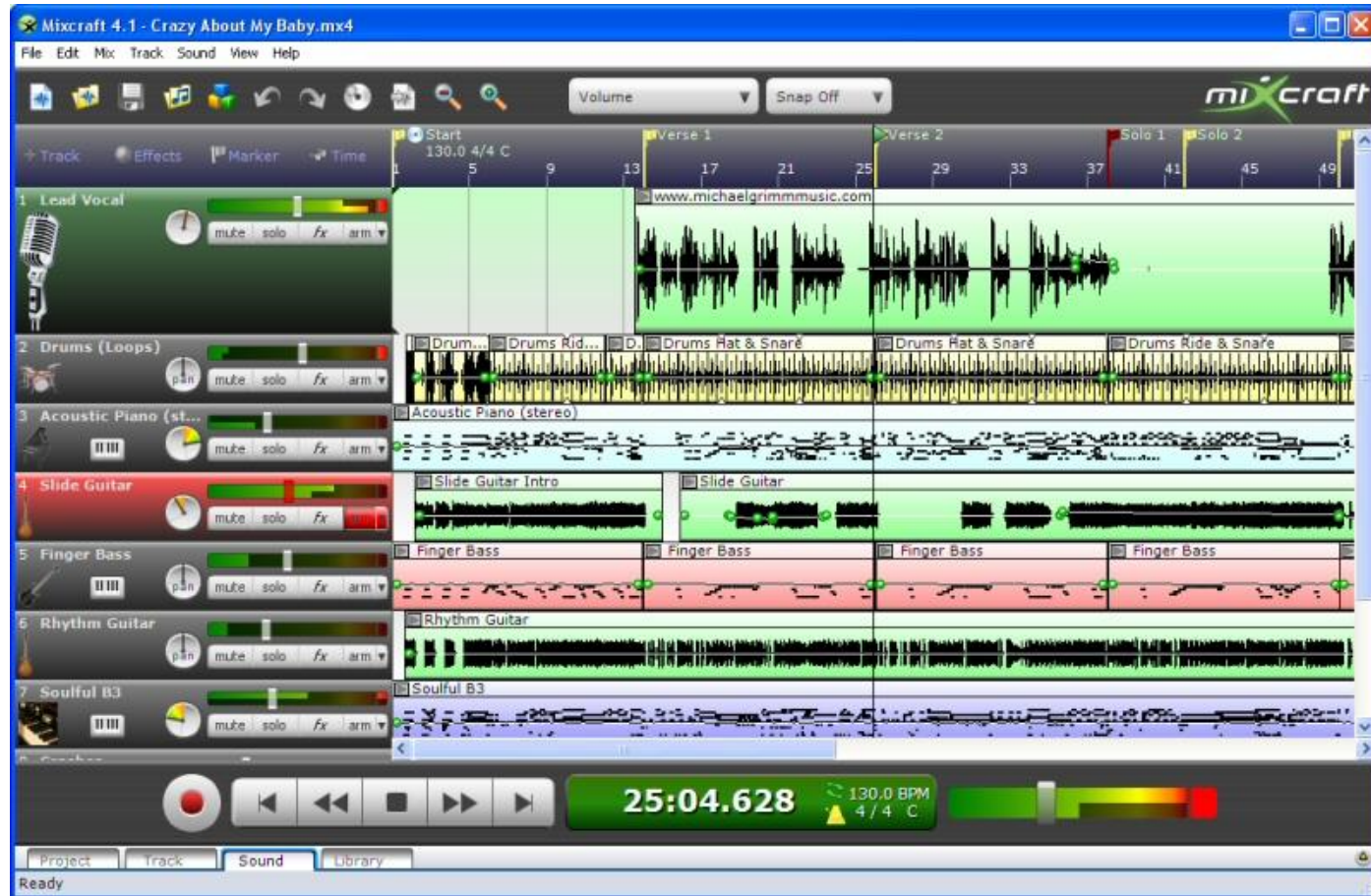
Event Editor

Goto... Filter... Insert:  PC      SX

Track = 9 STRINGS

Event	Measure	Chan	Data
	0001:01:240	9	G2 +123 +64 0000:00:240
	0001:02:000	9	G2 +123 +64 0000:00:240
	0001:02:240	9	G2 +123 +64 0000:00:240
	0002:01:000	9	D#2 +123 +64 0001:00:000
	0003:01:240	9	F2 +123 +64 0000:00:240
	0003:02:000	9	F2 +123 +64 0000:00:240
	0003:02:240	9	F2 +123 +64 0000:00:240
	0004:01:000	9	D2 +123 +64 0002:00:000

# Combining formats





# **Audio editing software**

- ProTools (Avid)
- Audition (Adobe)
- Garage Band (Apple)
- Logic (Apple)
- Nuendo (Steinberg)
- Audacity (open source)

# Conclusion

- Digital sound
  - Lots of data
  - Can record any sound
- MIDI
  - Small amount of data
  - Can only record digital musical instruments

# The End

