

Harmonic decomposition of a Vibroseis sweep using Gabor analysis

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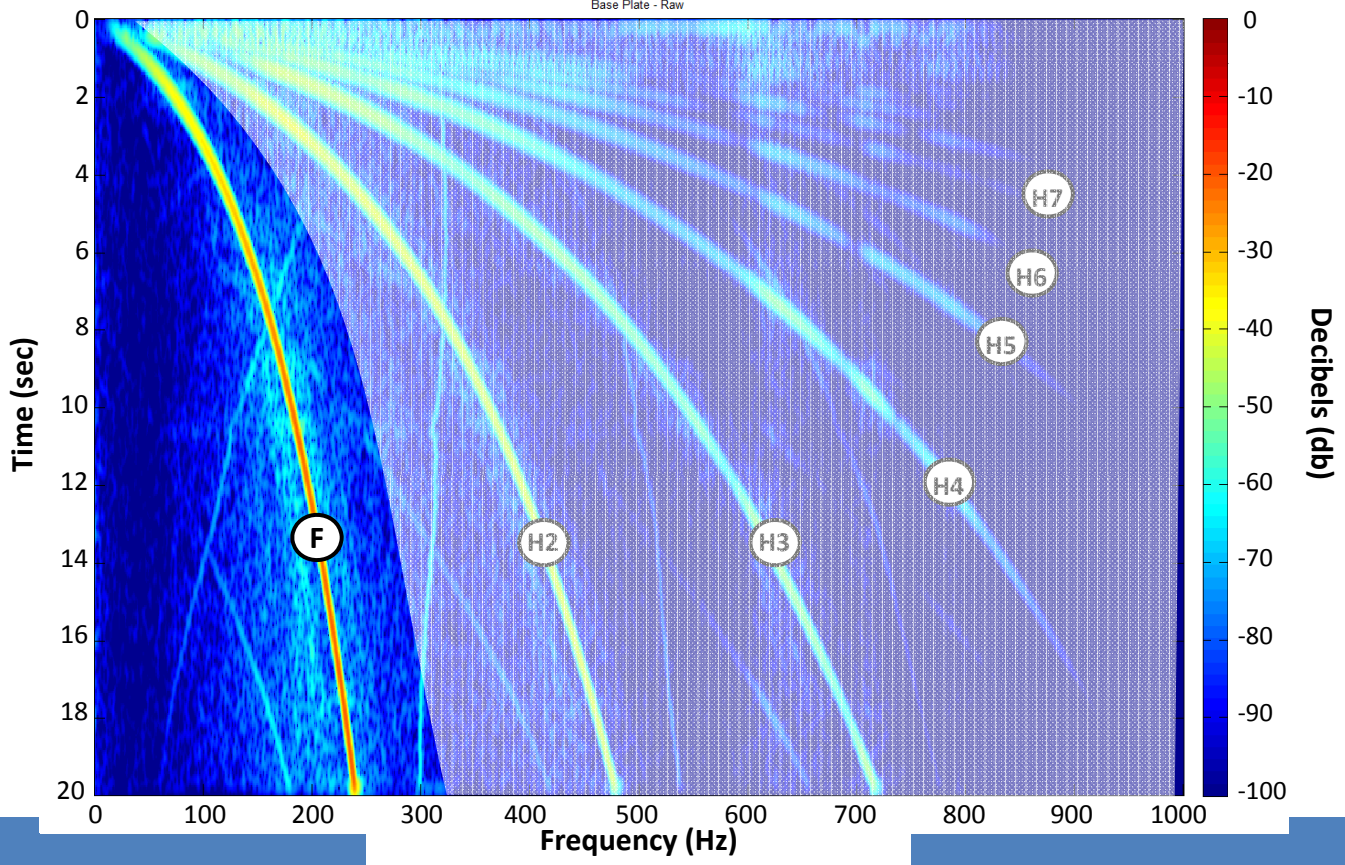
Andrew Barrett, Statoil

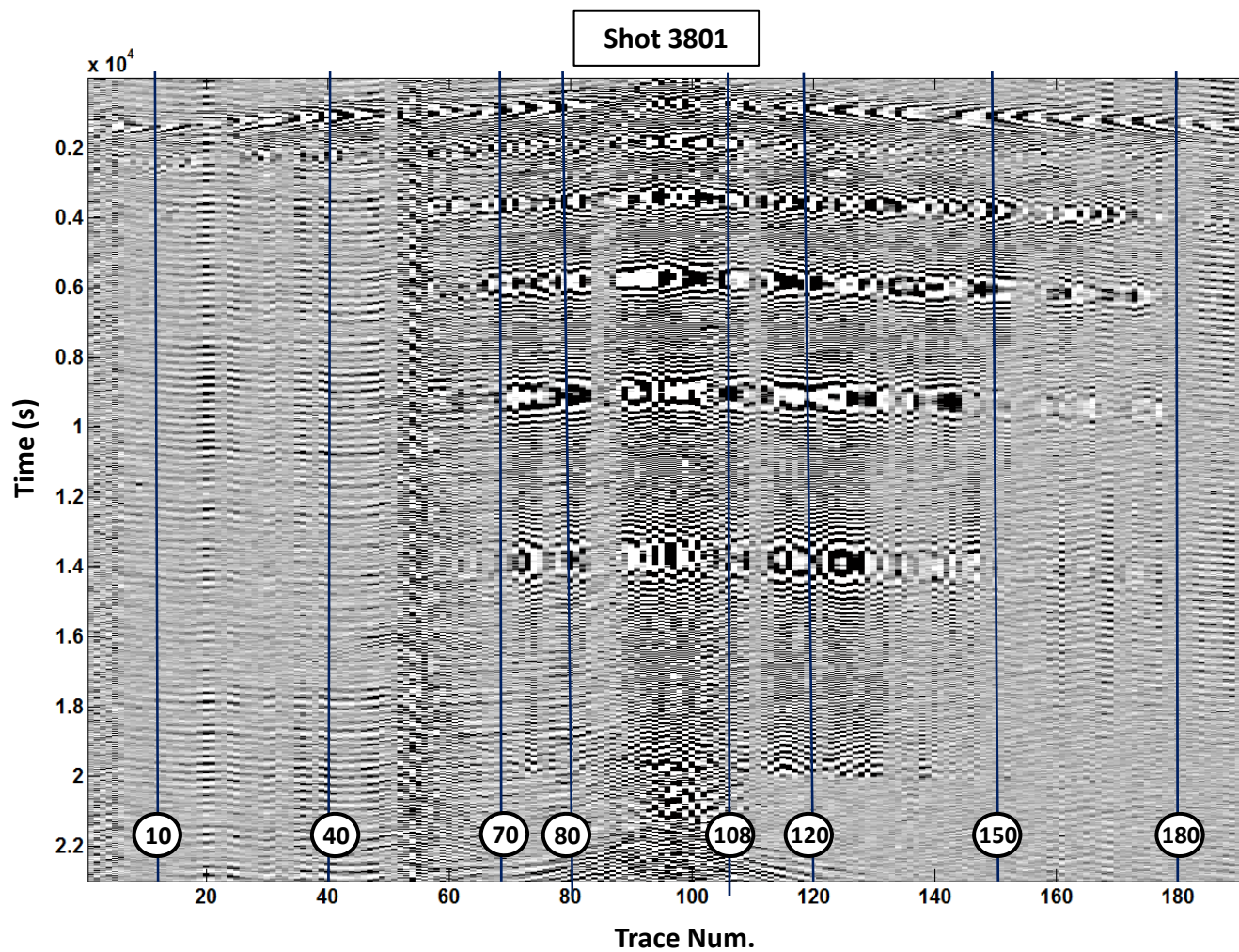
Structure

- Harmonics in a sweep
- Harmonics in traces
- Decomposition of a sweep
- Summary
- Future Work
- Acknowledgements

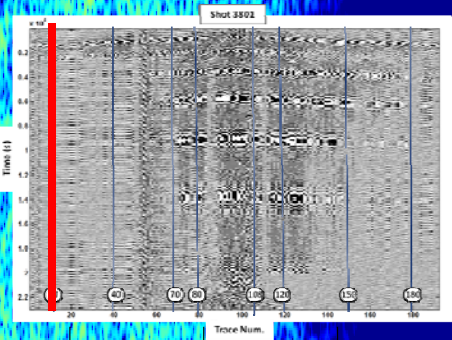
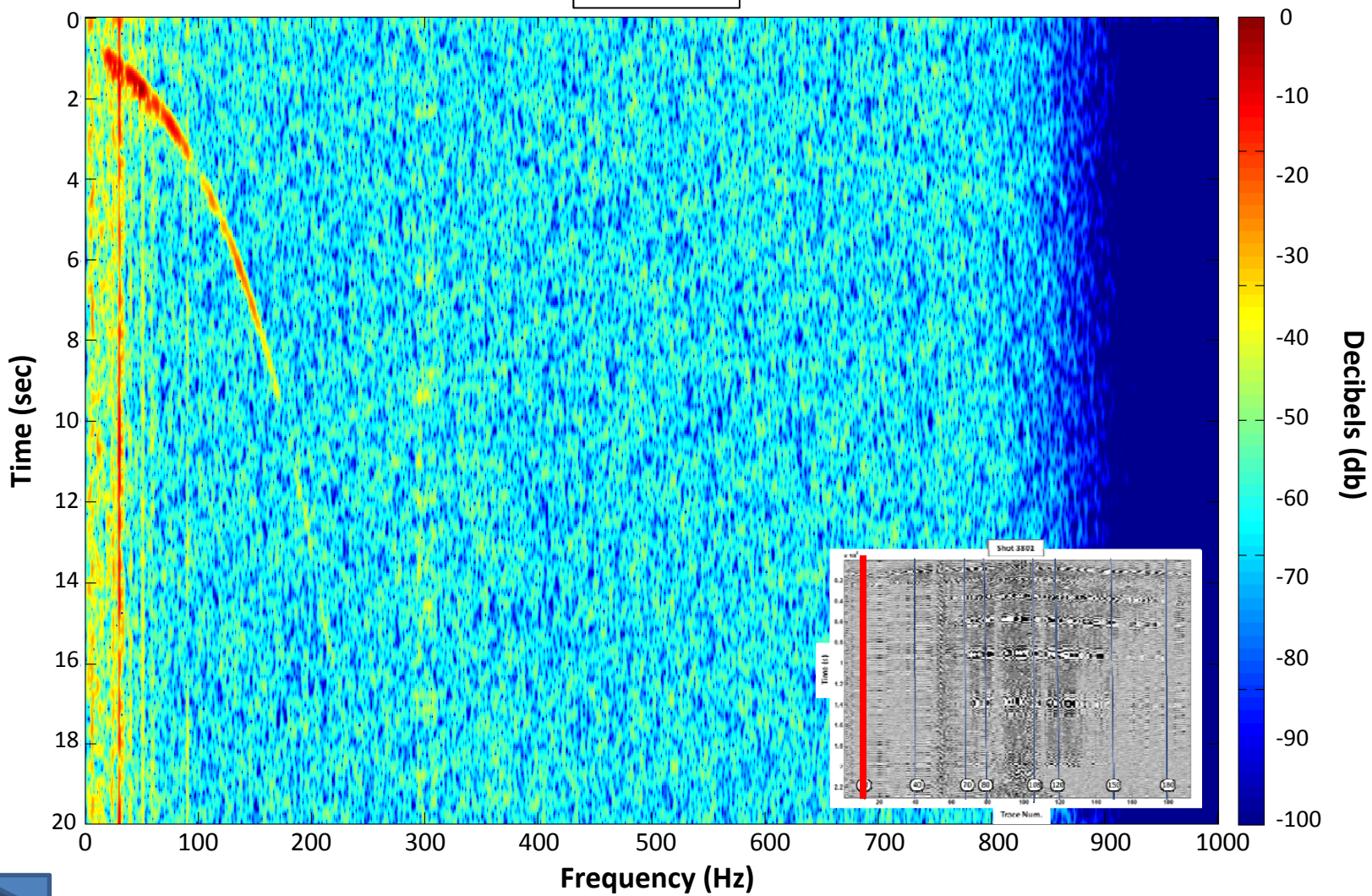


Base Plate - Raw

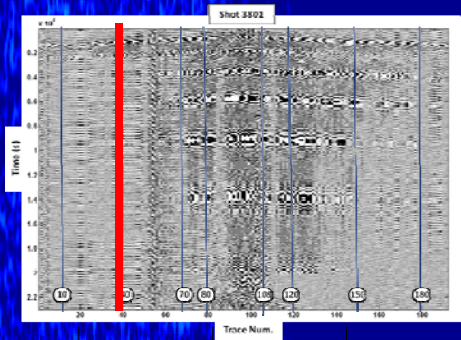
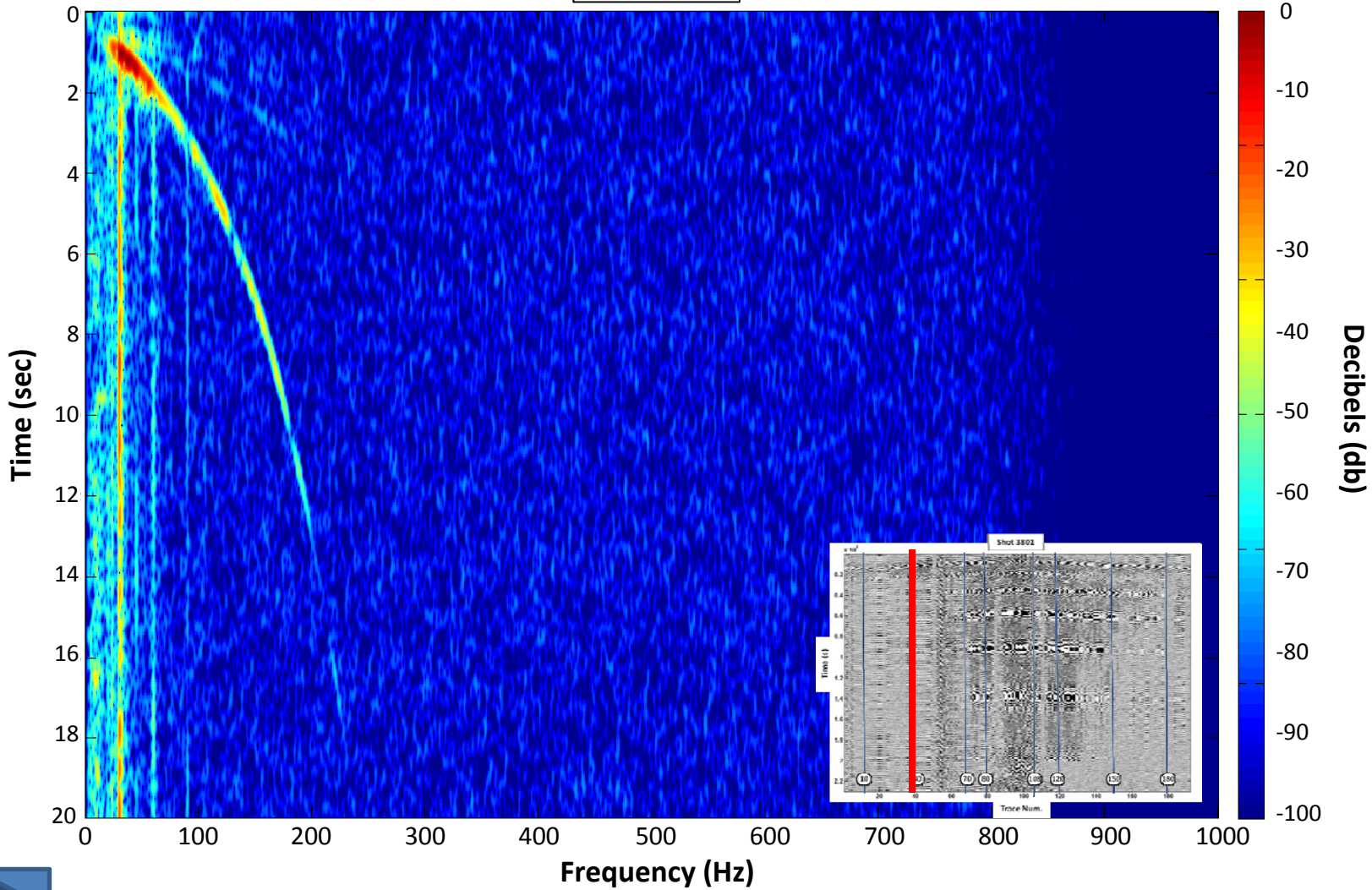




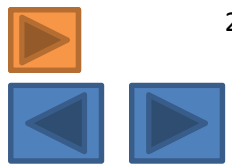
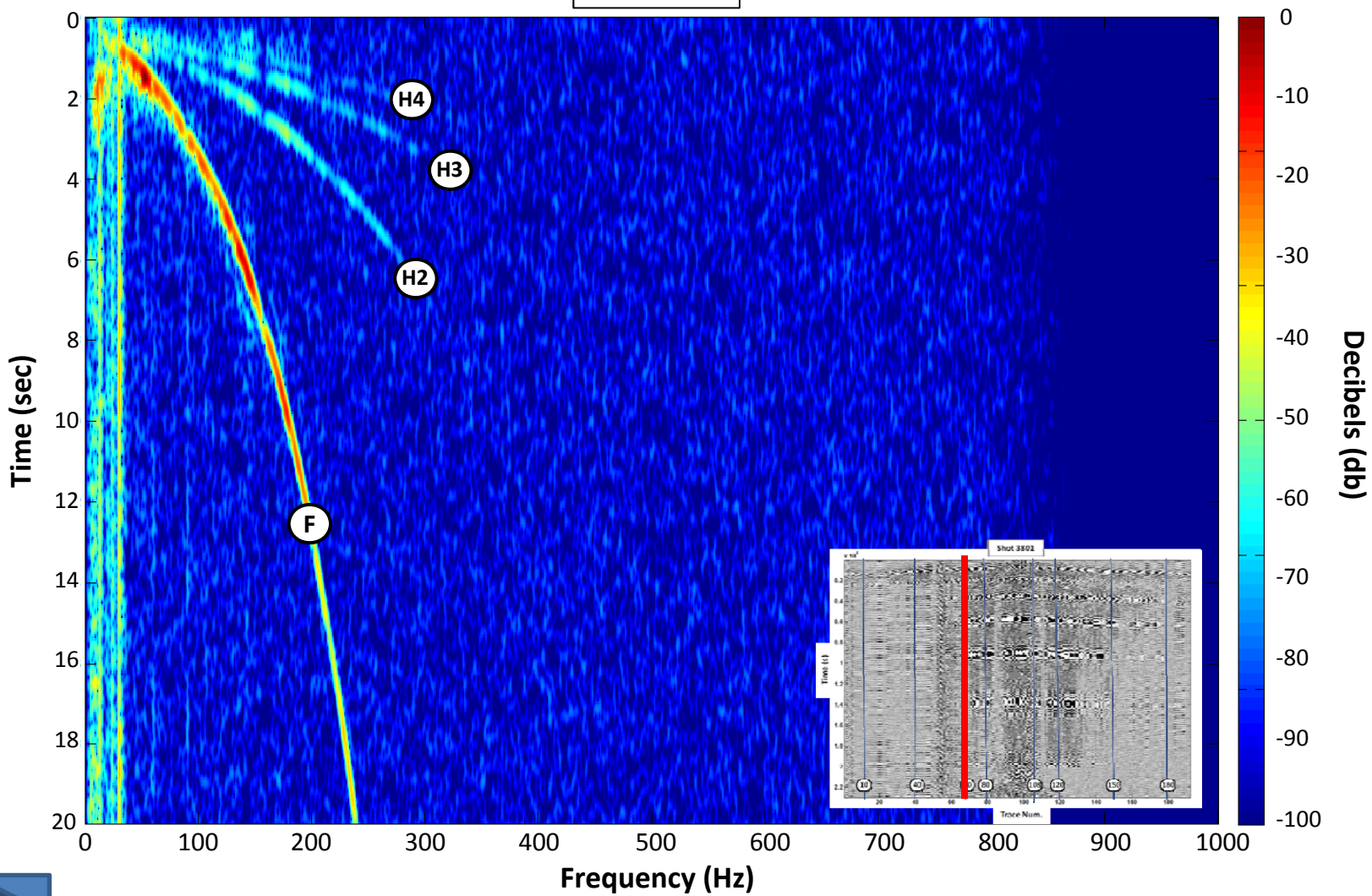
Trace 10



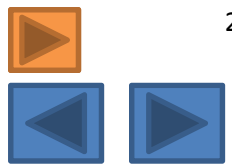
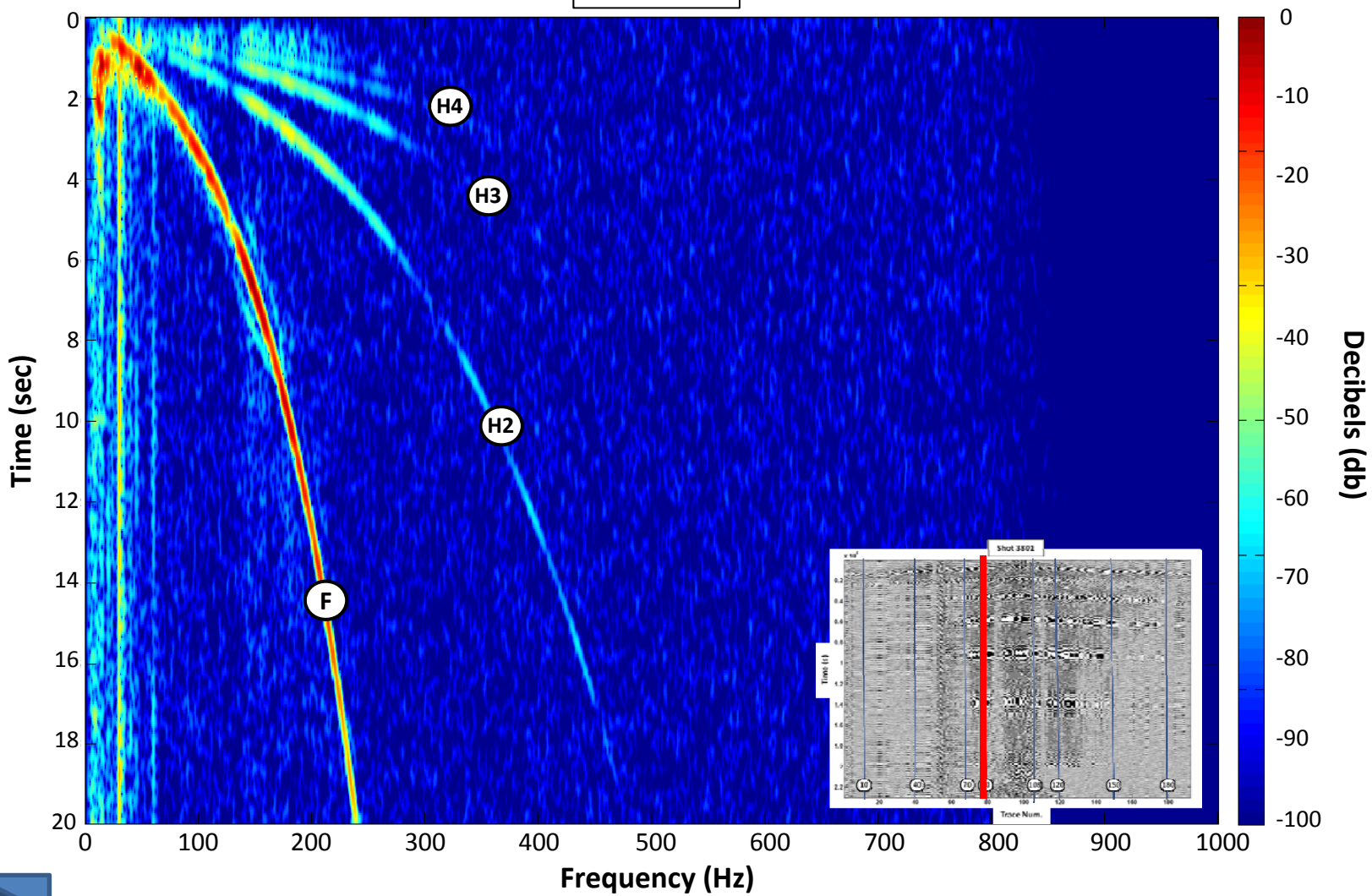
Trace 40



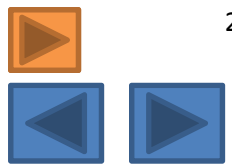
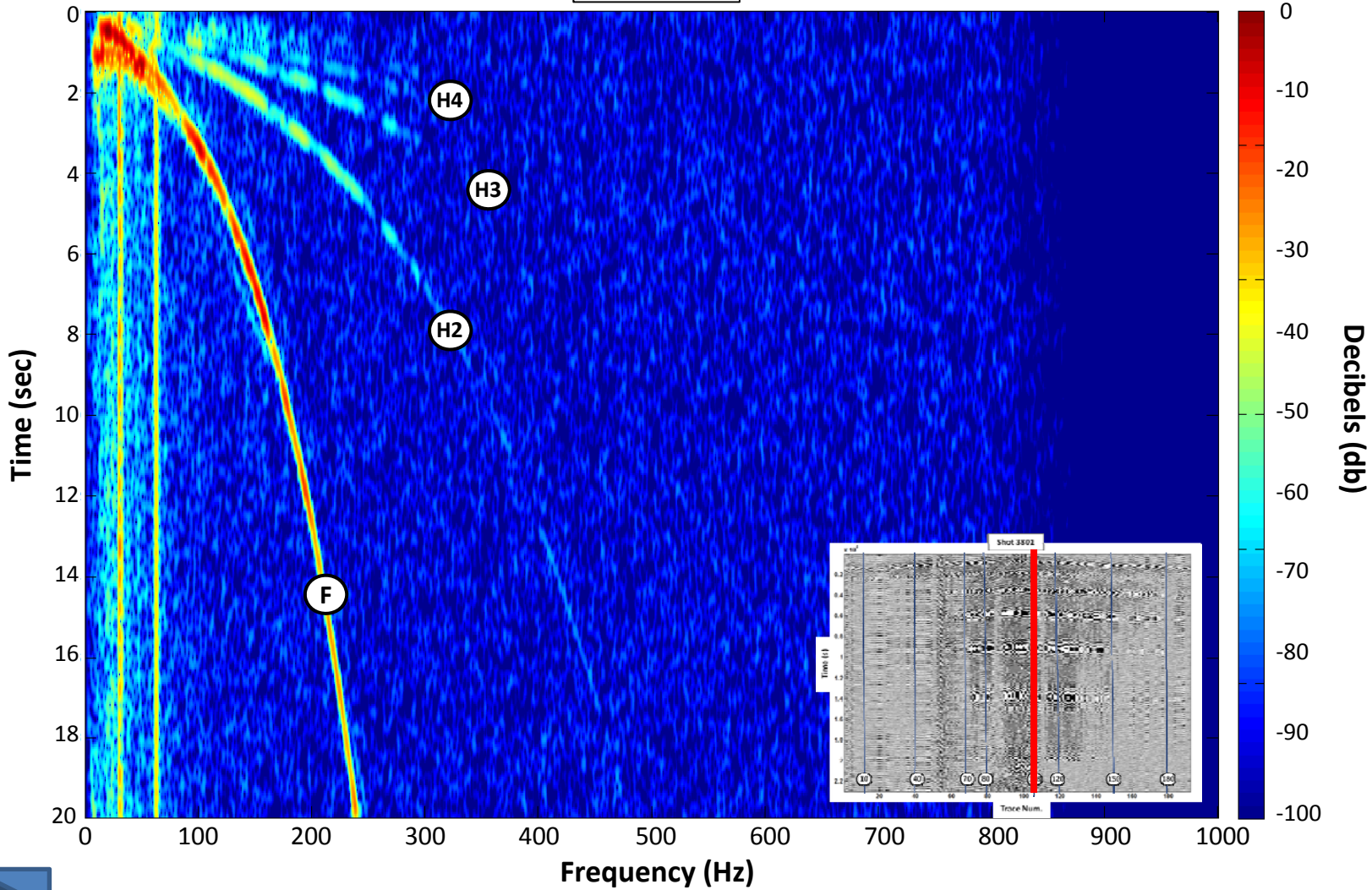
Trace 70



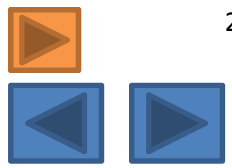
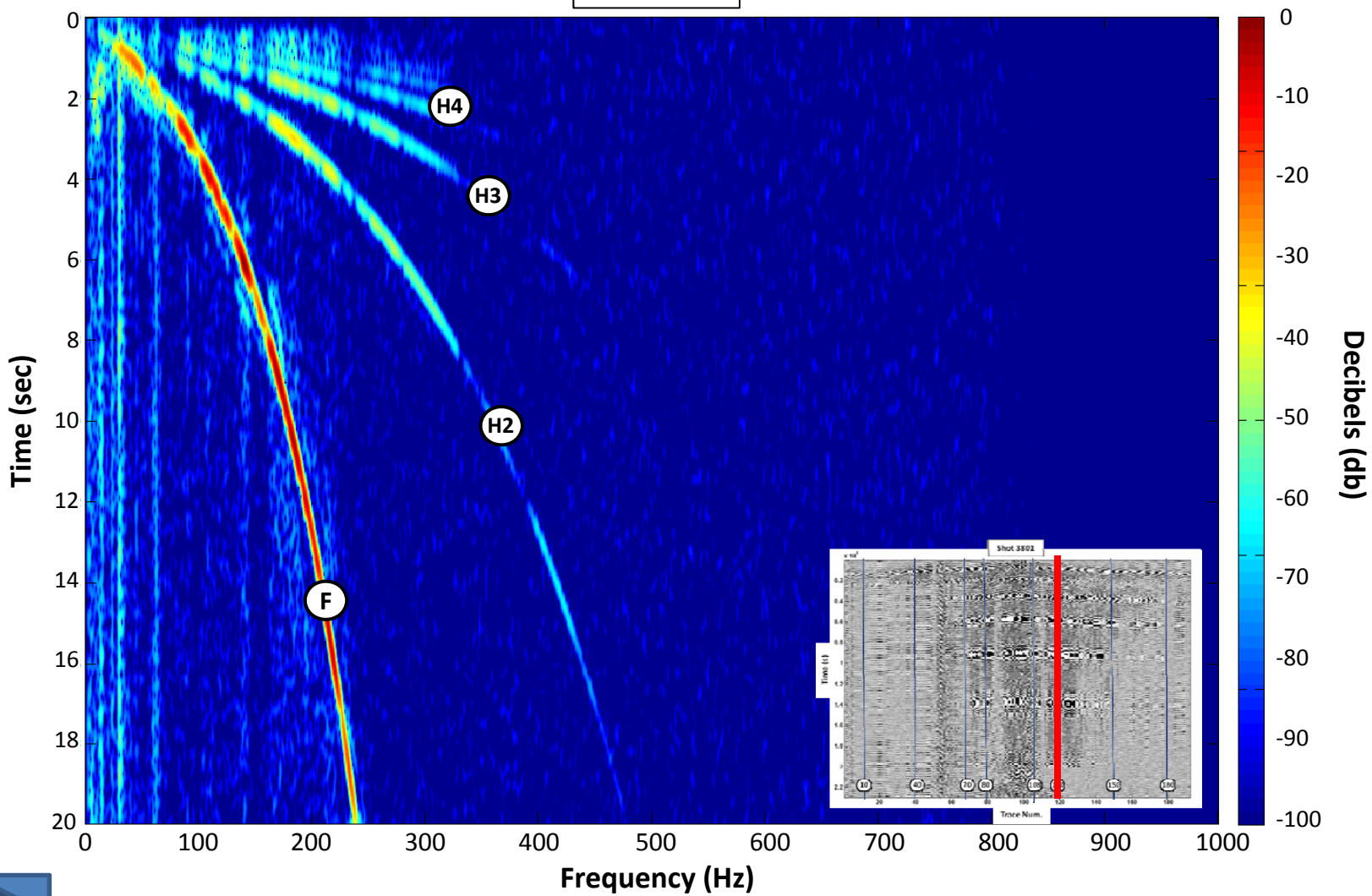
Trace 80



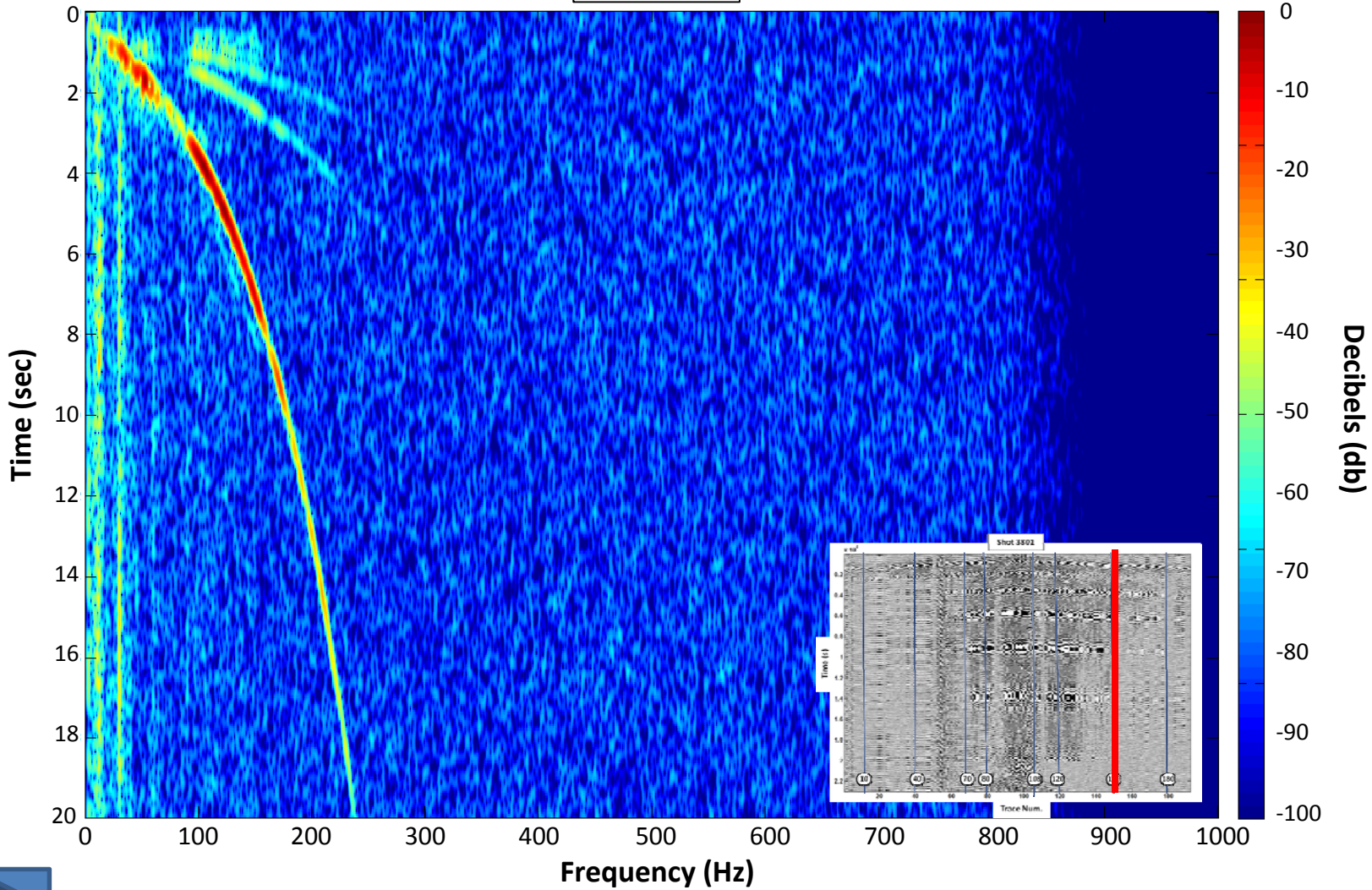
Trace 108



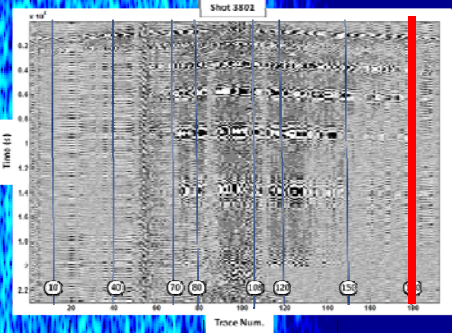
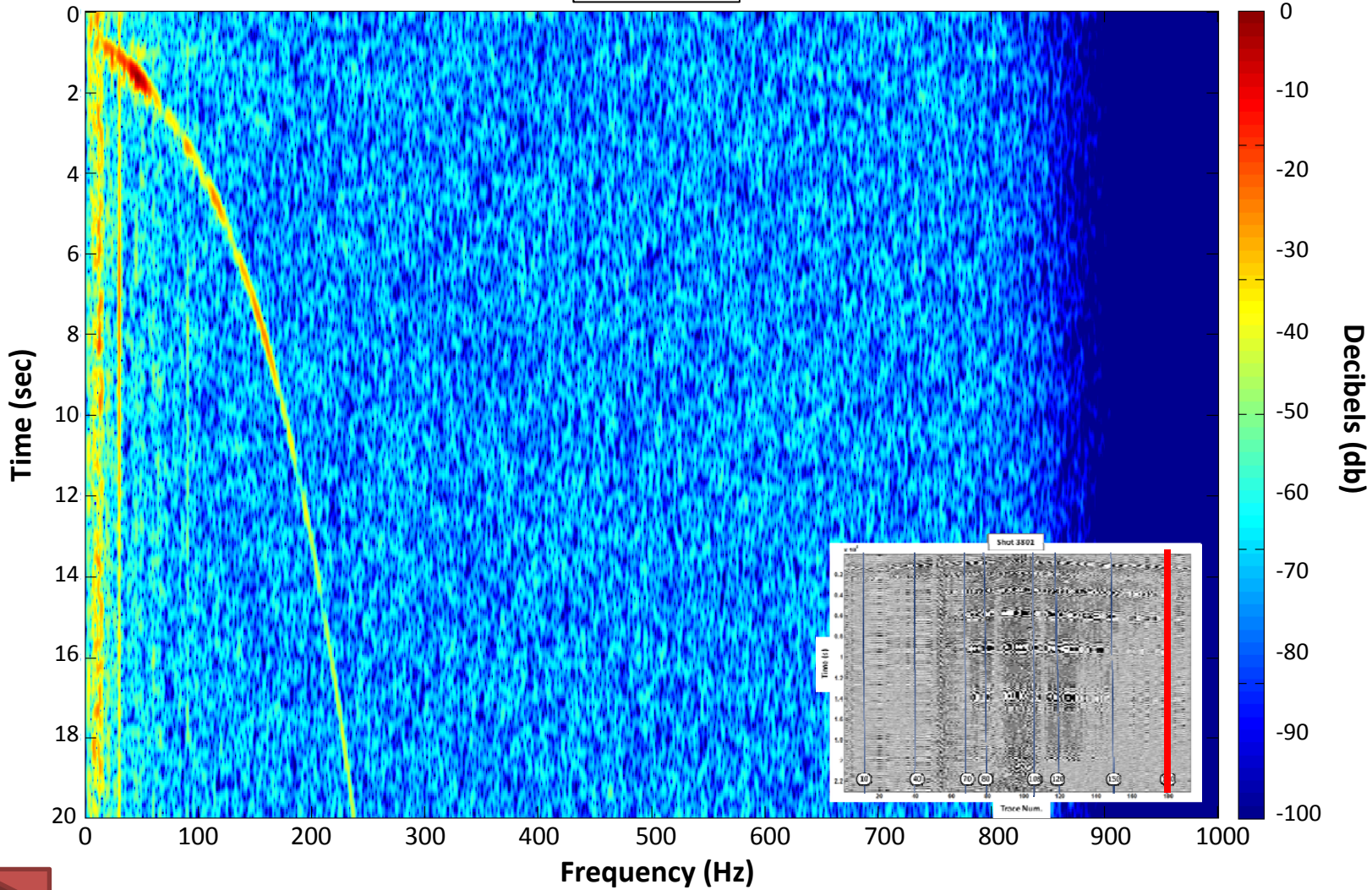
Trace 120



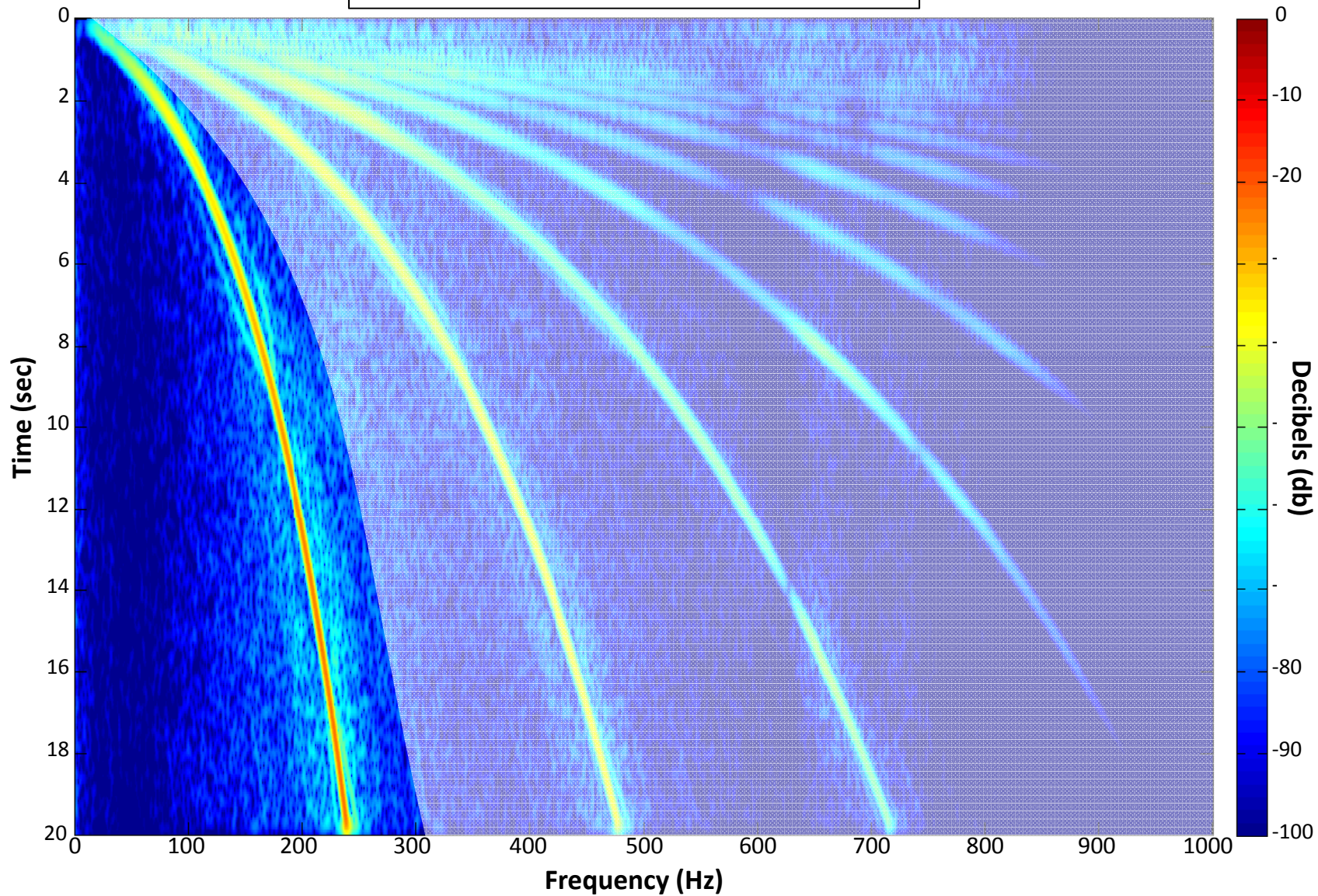
Trace 150



Trace 180



Sweep 3801 recorded at the baseplate



Solution

$$\sigma_{ds}(t) = \alpha_1 * \sigma_1(t) + \alpha_2 * \sigma_2(t) + \dots + \alpha_n * \sigma_n(t) + \dots$$

Distorted
Sweep

Fundamental

H2

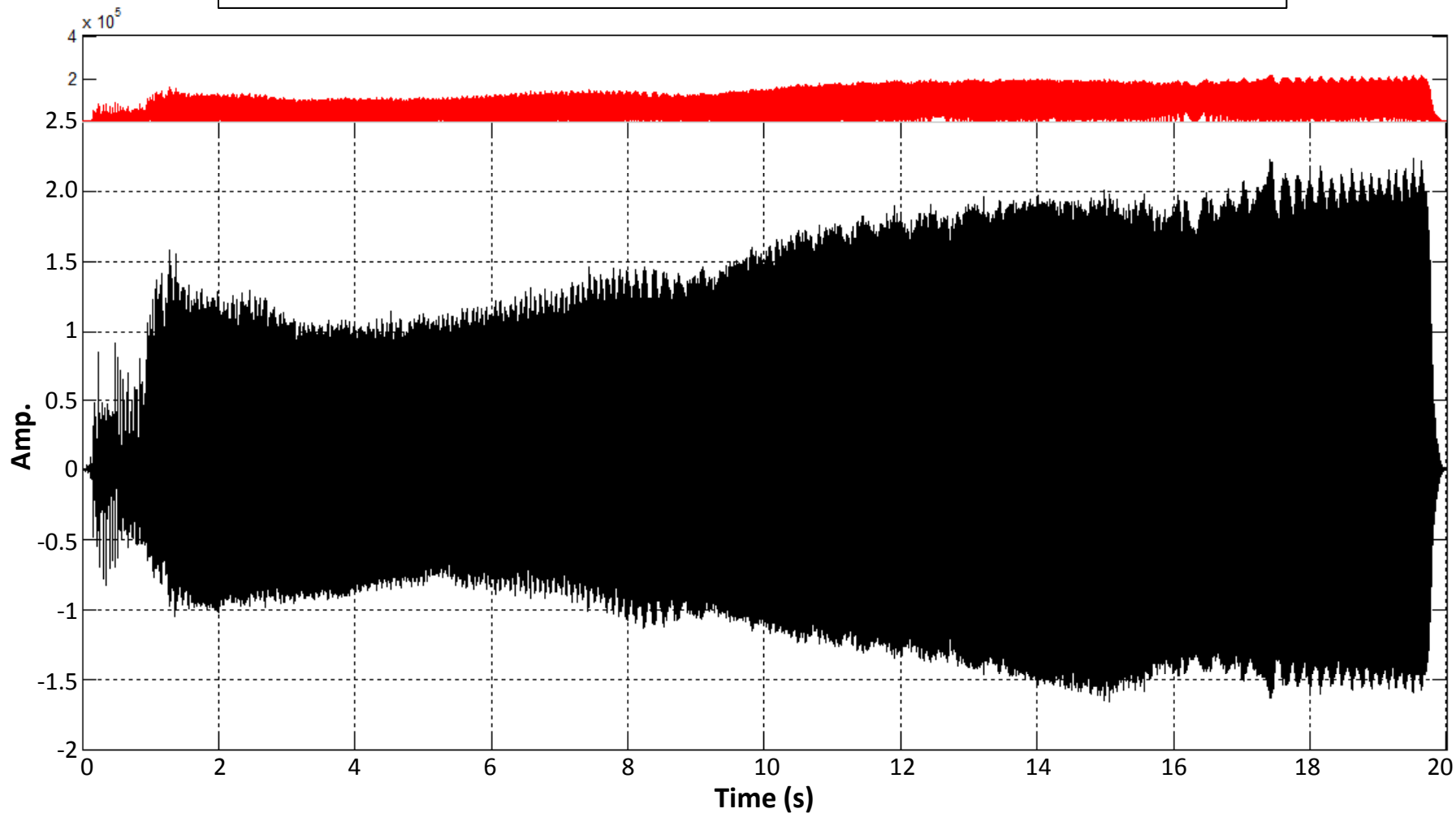
- Twice the fundamental

Hn

- High frequencies
attenuated through earth
-H4 max. in traces
- H9 max. in sweep

- Using least squares
- **Time stationary decomposition**
 - Time dependant amplitudes
- **Frequency stationary decomposition**
 - Calculates a phase rotation
- **Time / frequency dependant Gabor decomposition**
 - Most general result
 - Frequency dependant Gabor decomposition is superior (present algorithm)
- Refer to our CREWES paper for full derivation of results

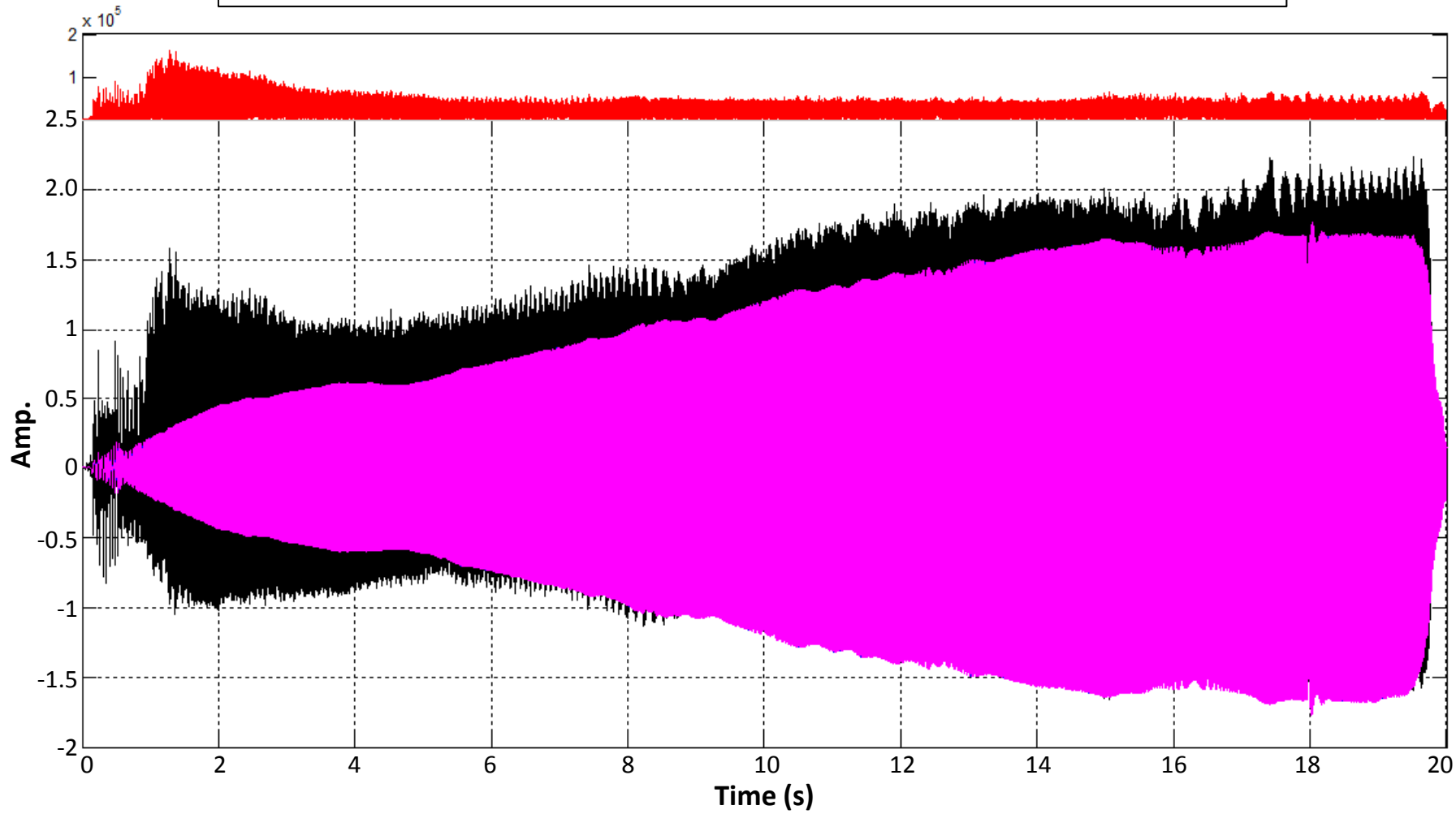
Sweep 3801 recorded at the baseplate



Black – Baseplate **Blue** – Sequentially combined components **Magenta** – Current component



Fundamental (Magenta)

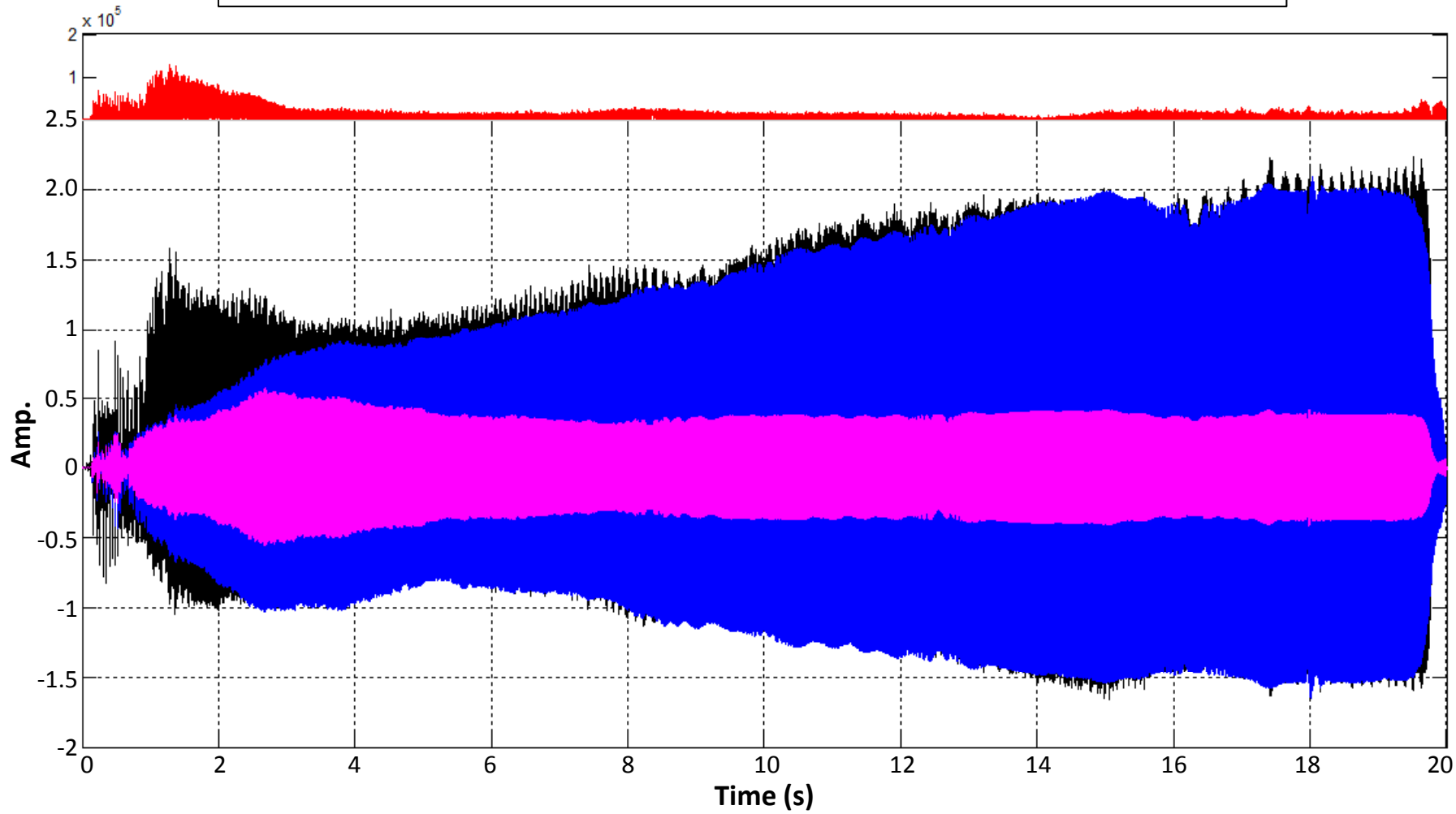


Black – Baseplate **Blue** – Sequentially combined components **Magenta** – Current component



Time Domain - [Frequency Domain](#) - [Gabor Domain](#)

H2(Magenta)

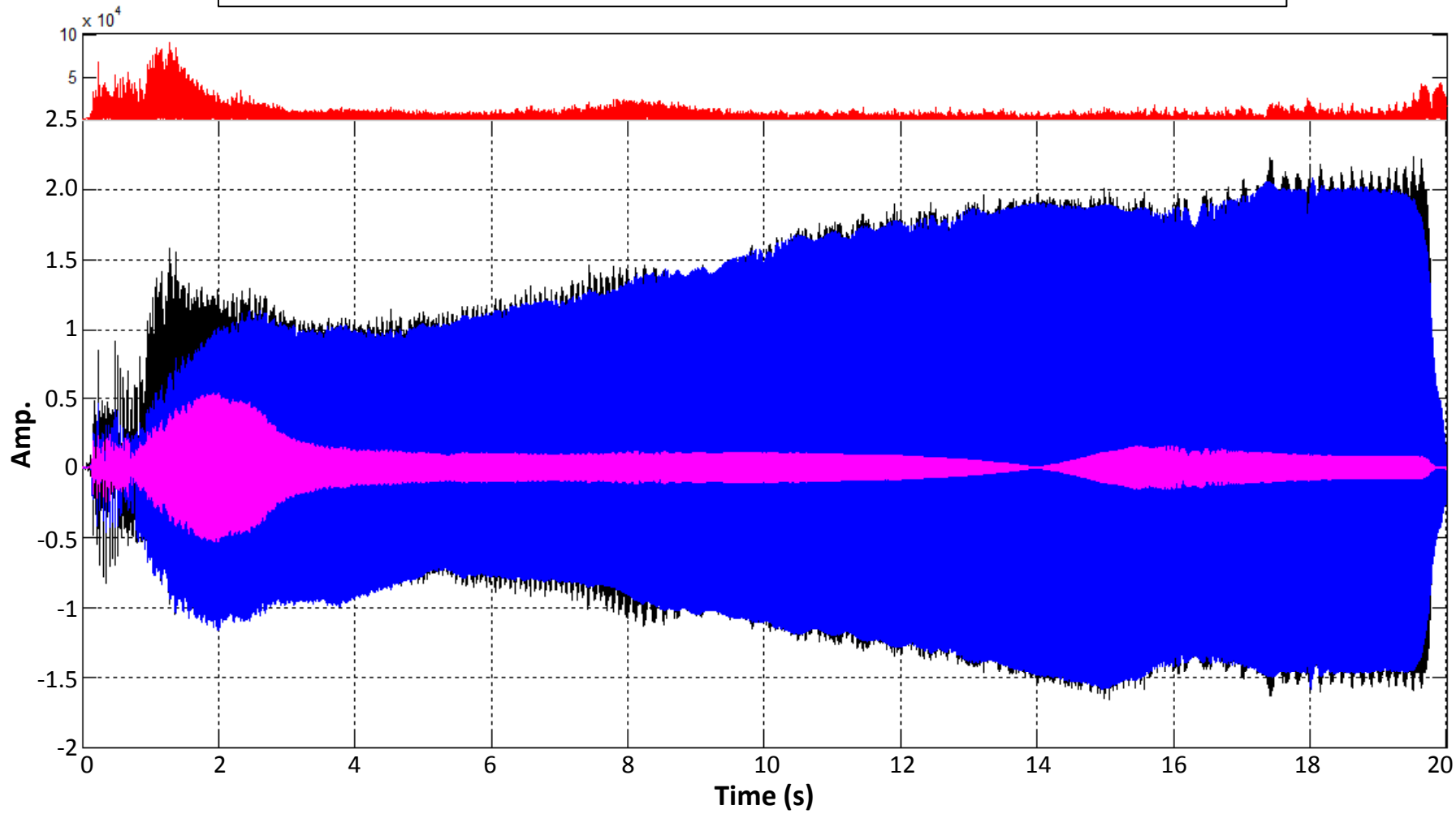


Black – Baseplate **Blue** – Sequentially combined components **Magenta** – Current component



Time Domain - [Frequency Domain](#) - [Gabor Domain](#)

H3 (Magenta)

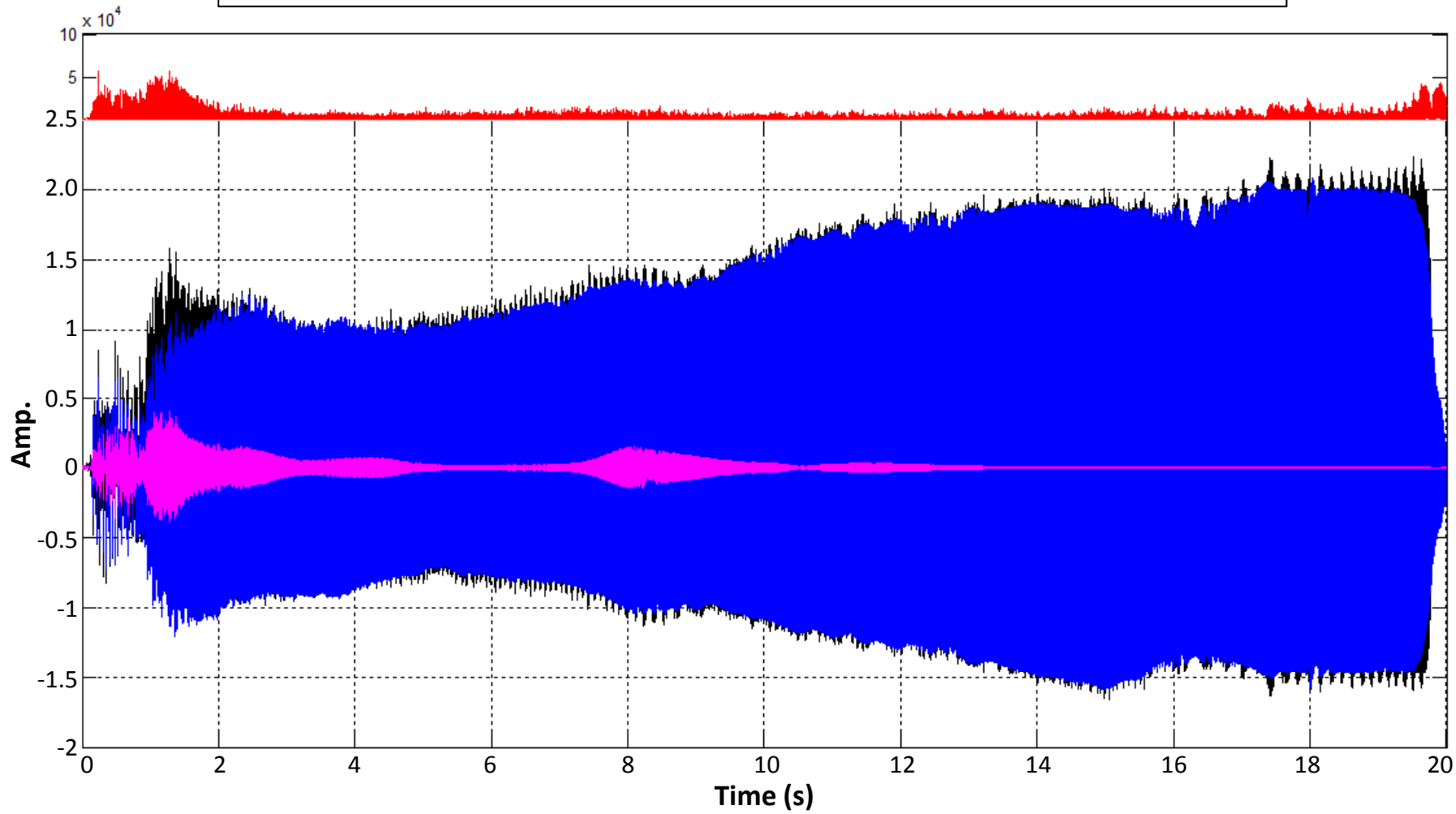


Black – Baseplate **Blue** – Sequentially combined components **Magenta** – Current component



Time Domain - [Frequency Domain](#) - [Gabor Domain](#)

H4 (Magenta)

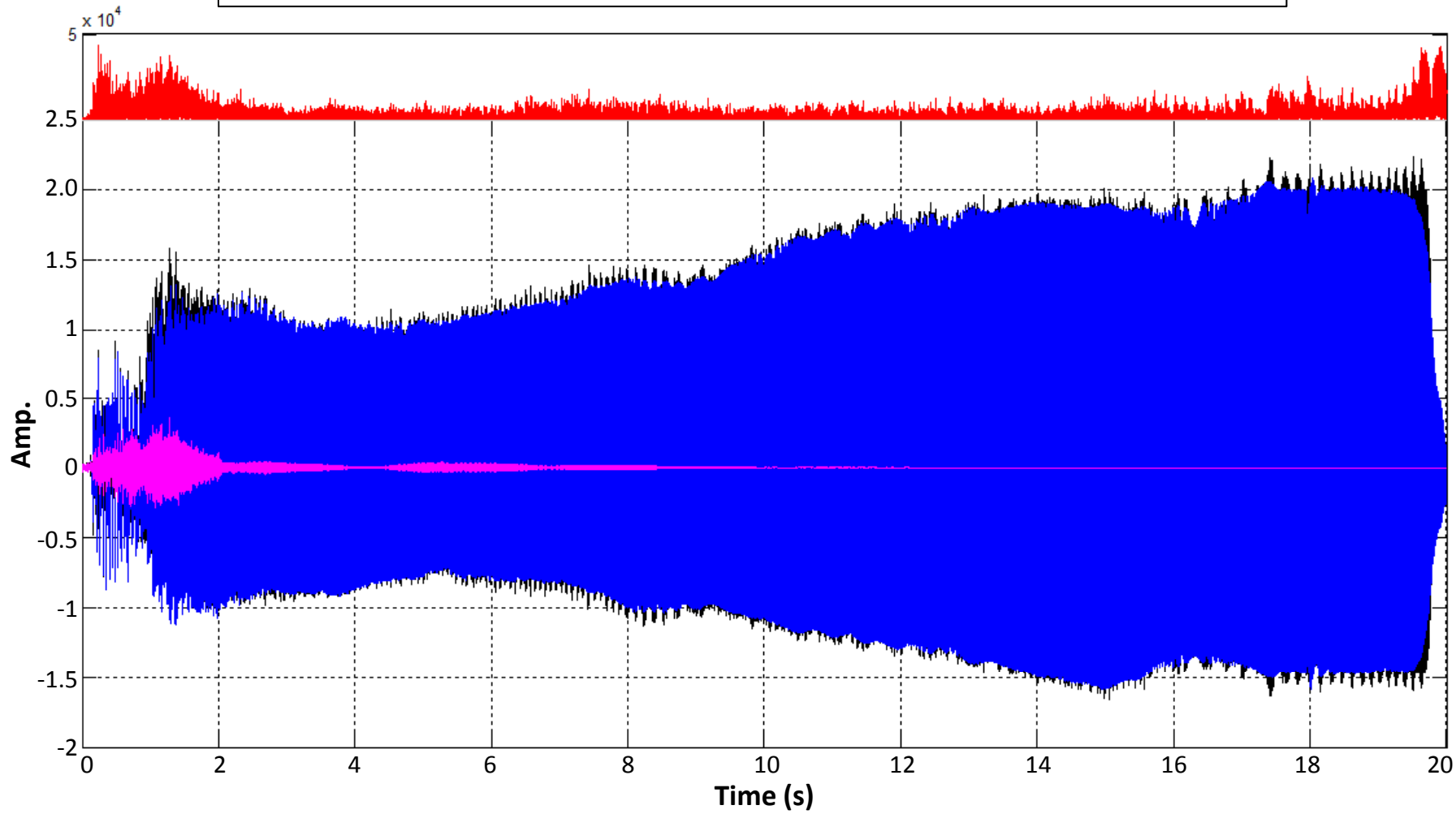


Black – Baseplate **Blue** – Sequentially combined components **Magenta** – Current component



Time Domain - [Frequency Domain](#) - [Gabor Domain](#)

H5 (Magenta)

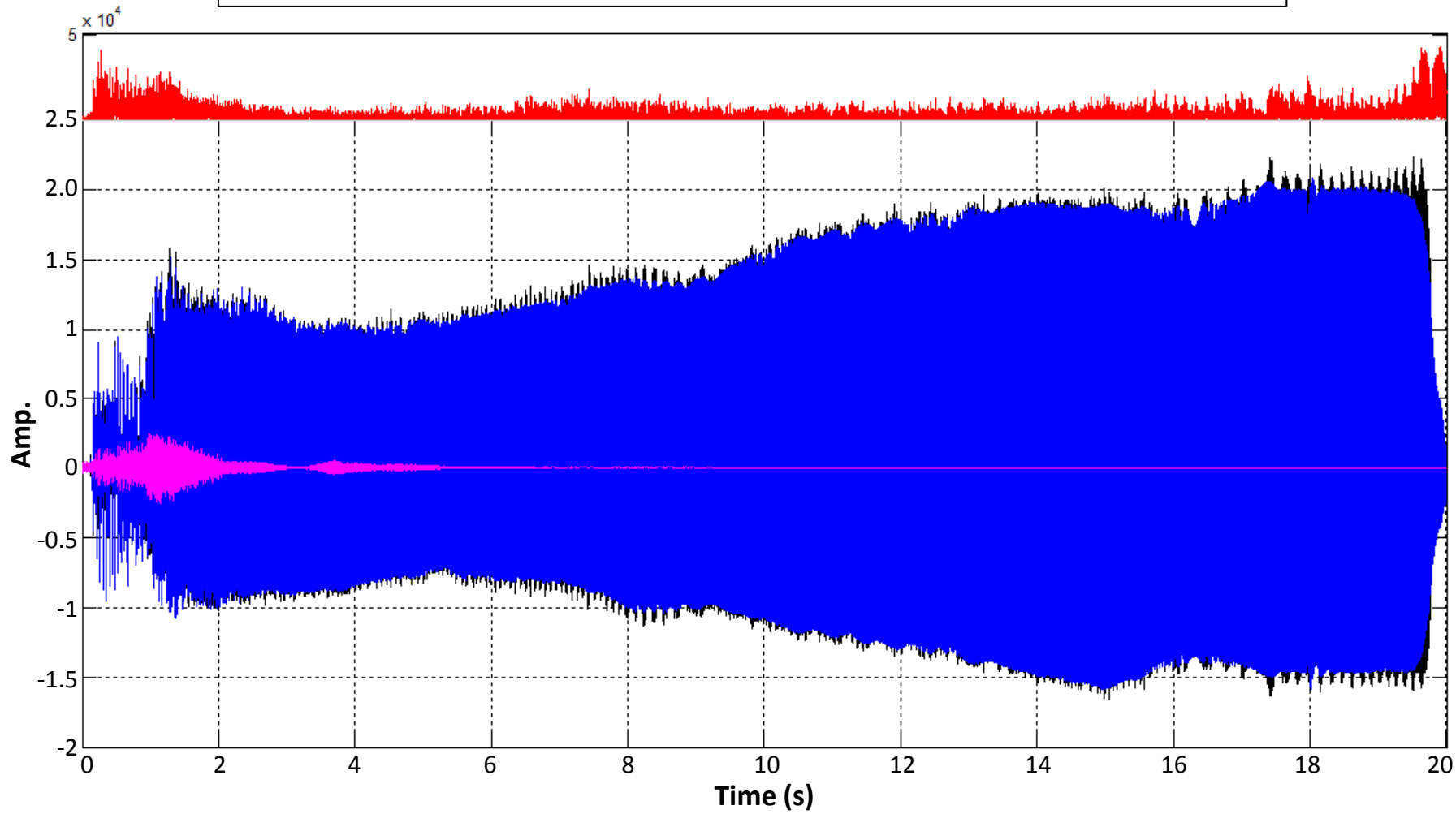


Black – Baseplate **Blue** – Sequentially combined components **Magenta** – Current component



Time Domain - [Frequency Domain](#) - [Gabor Domain](#)

H6 (Magenta)

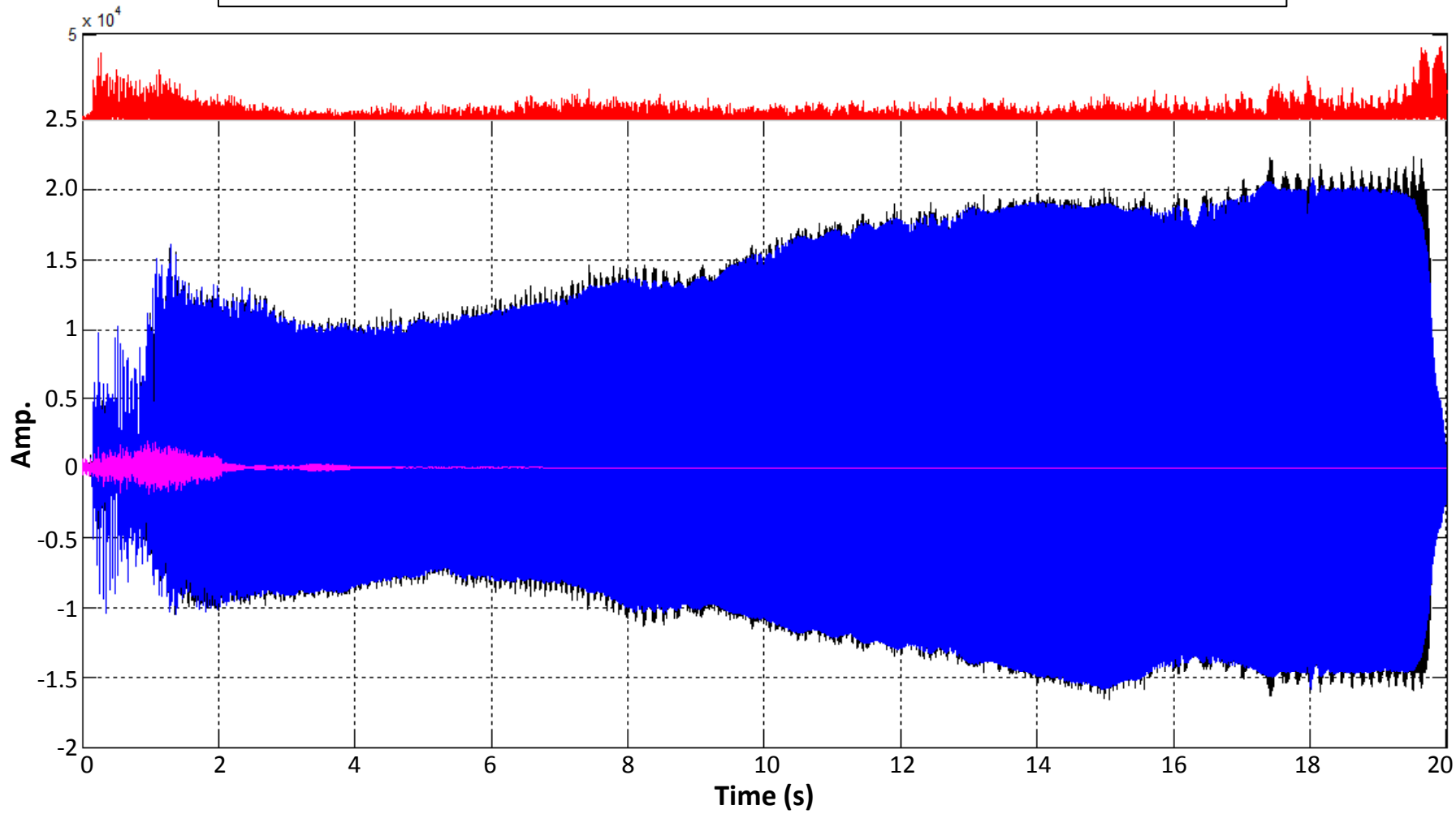


Black – Baseplate **Blue** – Sequentially combined components **Magenta** – Current component



Time Domain - [Frequency Domain](#) - [Gabor Domain](#)

H7 (Magenta)

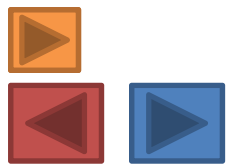
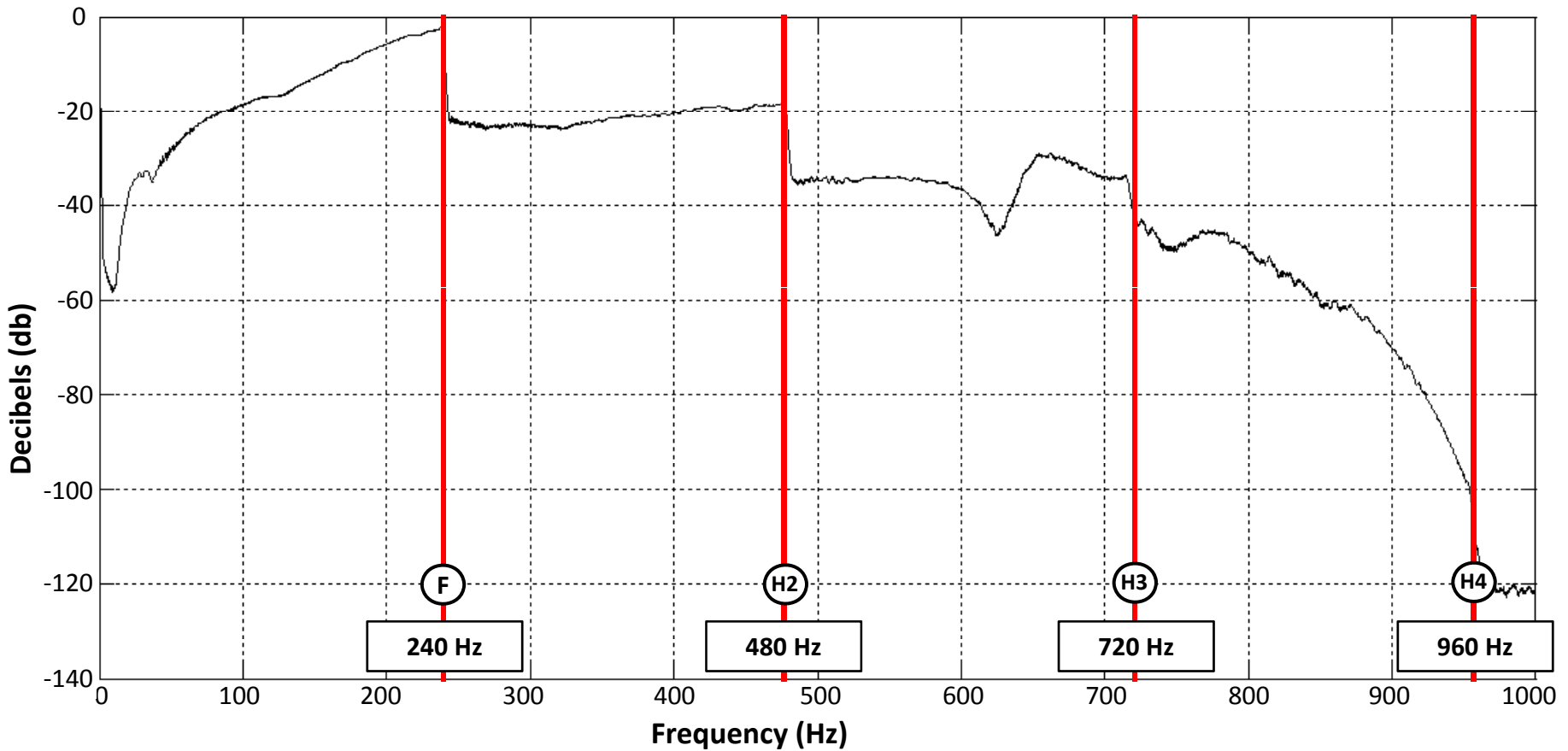


Black – Baseplate **Blue** – Sequentially combined components **Magenta** – Current component



Time Domain - [Frequency Domain](#) - [Gabor Domain](#) - [Final Comparison](#)

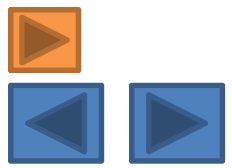
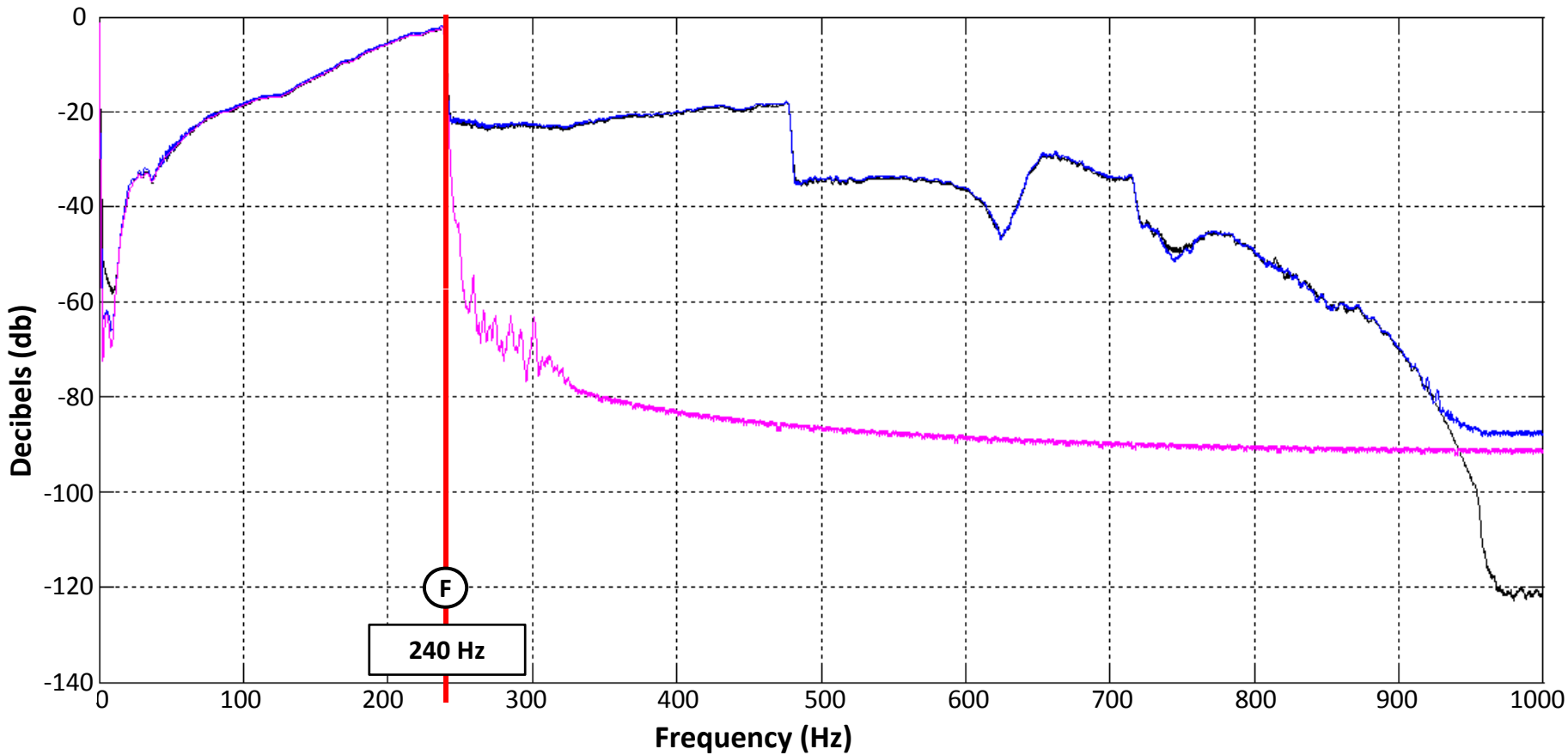
Sweep 3801 recorded at the baseplate



Black – Baseplate **Blue** – Combined components **Magenta** – Current component

[Time Domain](#) - Frequency Domain - [Gabor Domain](#) [Gabor Domain End](#)

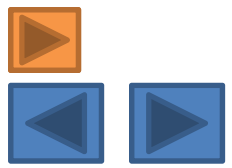
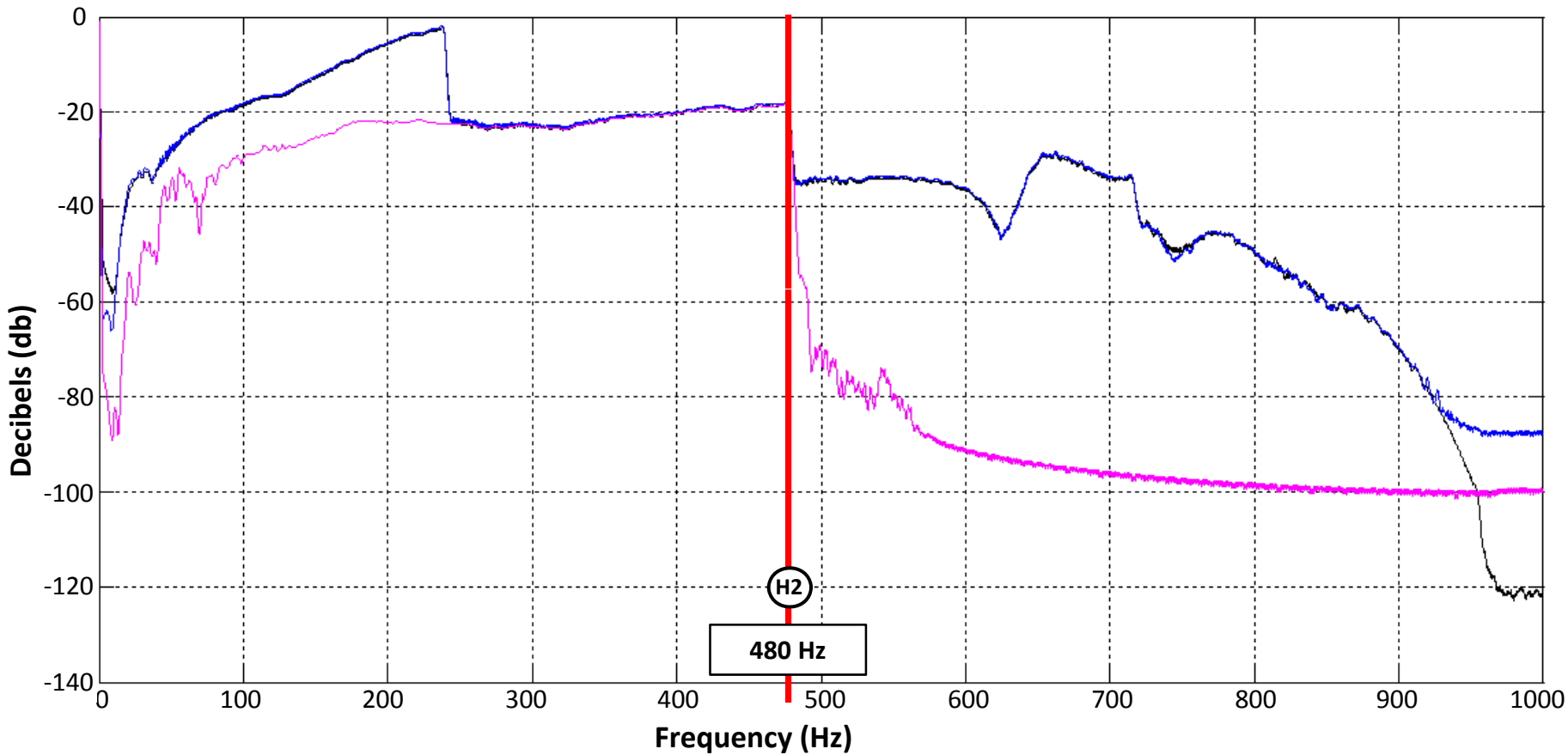
Fundamental (Magenta)



Black - Baseplate **Blue** - Combined components **Magenta** - Current component

[Time Domain](#) - Frequency Domain - [Gabor Domain](#)

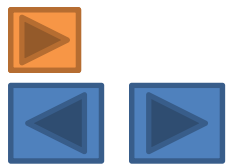
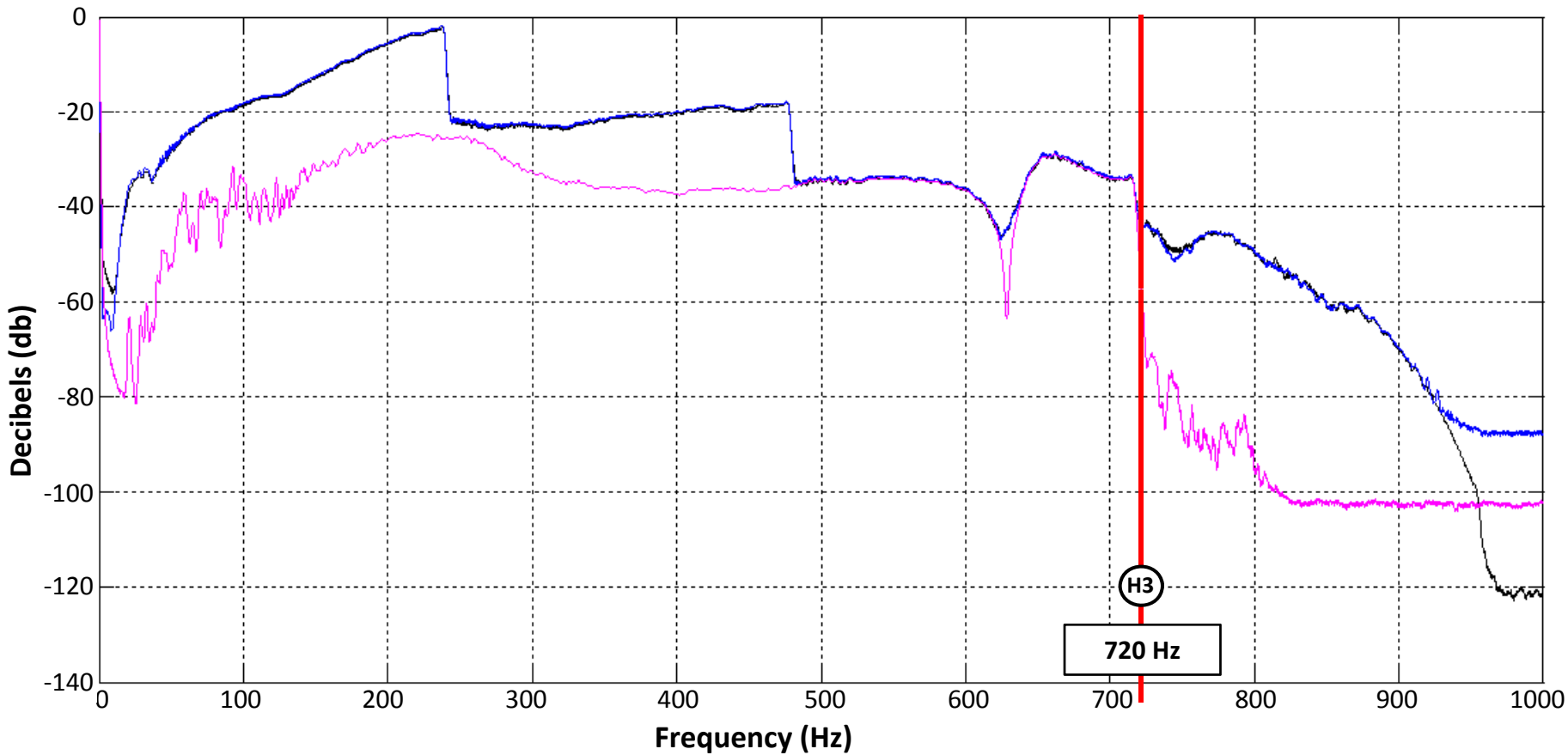
H2(Magenta)



Black – Baseplate **Blue** – Combined components **Magenta** – Current component

[Time Domain](#) - Frequency Domain - [Gabor Domain](#)

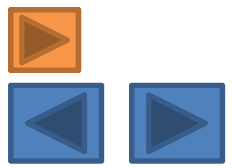
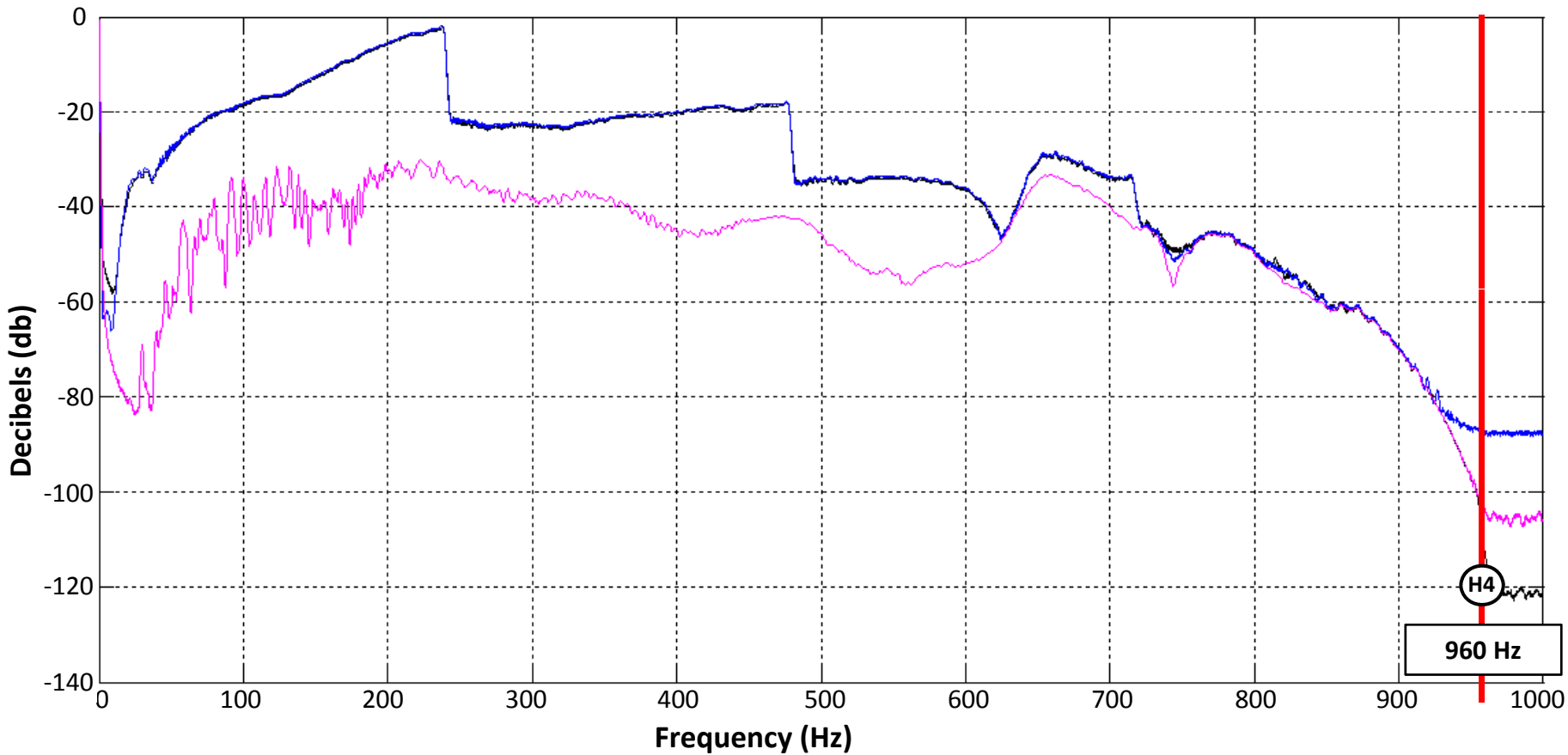
H3 (Magenta)



Black – Baseplate **Blue** – Combined components **Magenta** – Current component

[Time Domain](#) - Frequency Domain - [Gabor Domain](#)

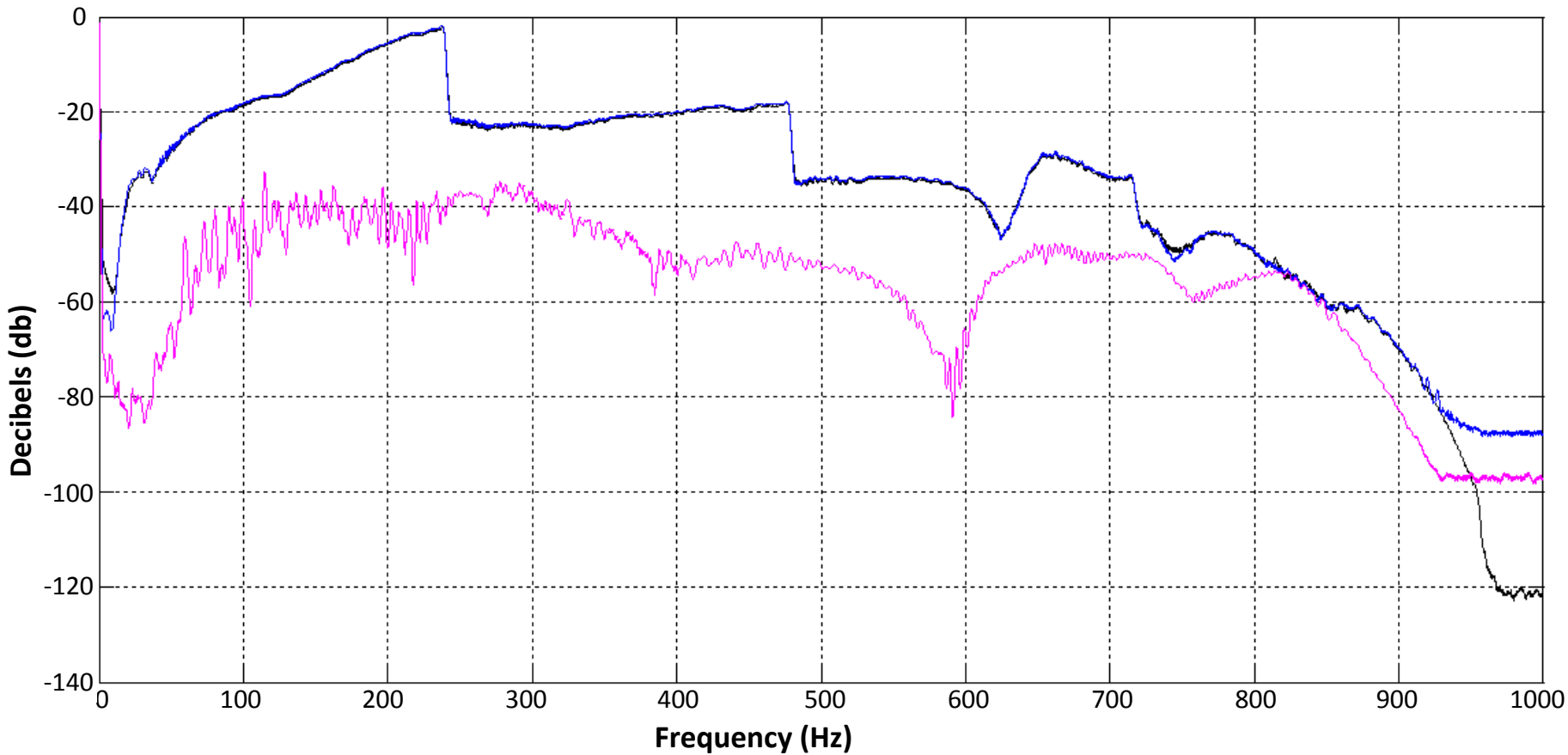
H4 (Magenta)



Black – Baseplate **Blue** – Combined components **Magenta** – Current component

[Time Domain](#) - Frequency Domain - [Gabor Domain](#)

H5 (Magenta)

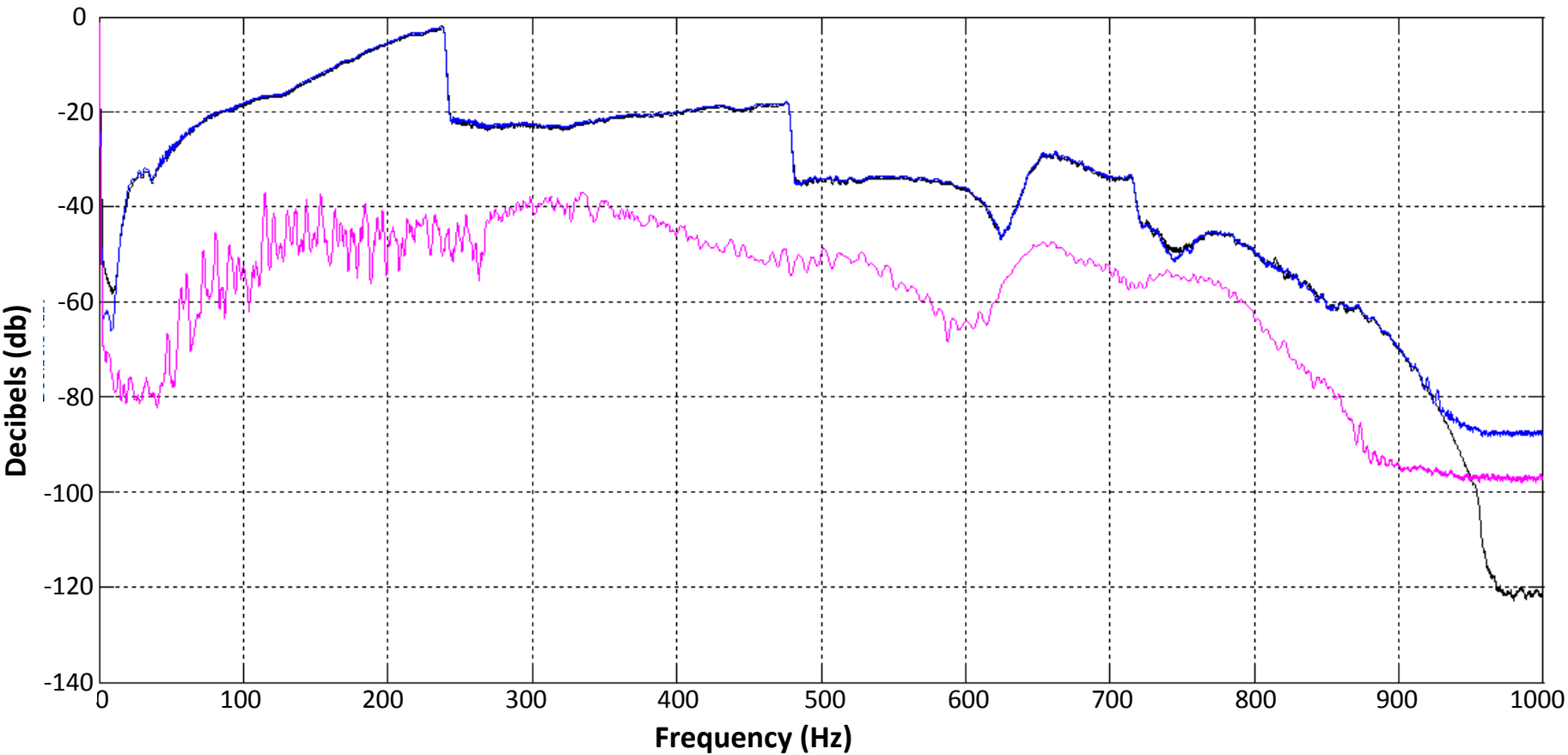


Black – Baseplate **Blue** – Combined components **Magenta** – Current component



[Time Domain](#) - Frequency Domain - [Gabor Domain](#)

H6 (Magenta)

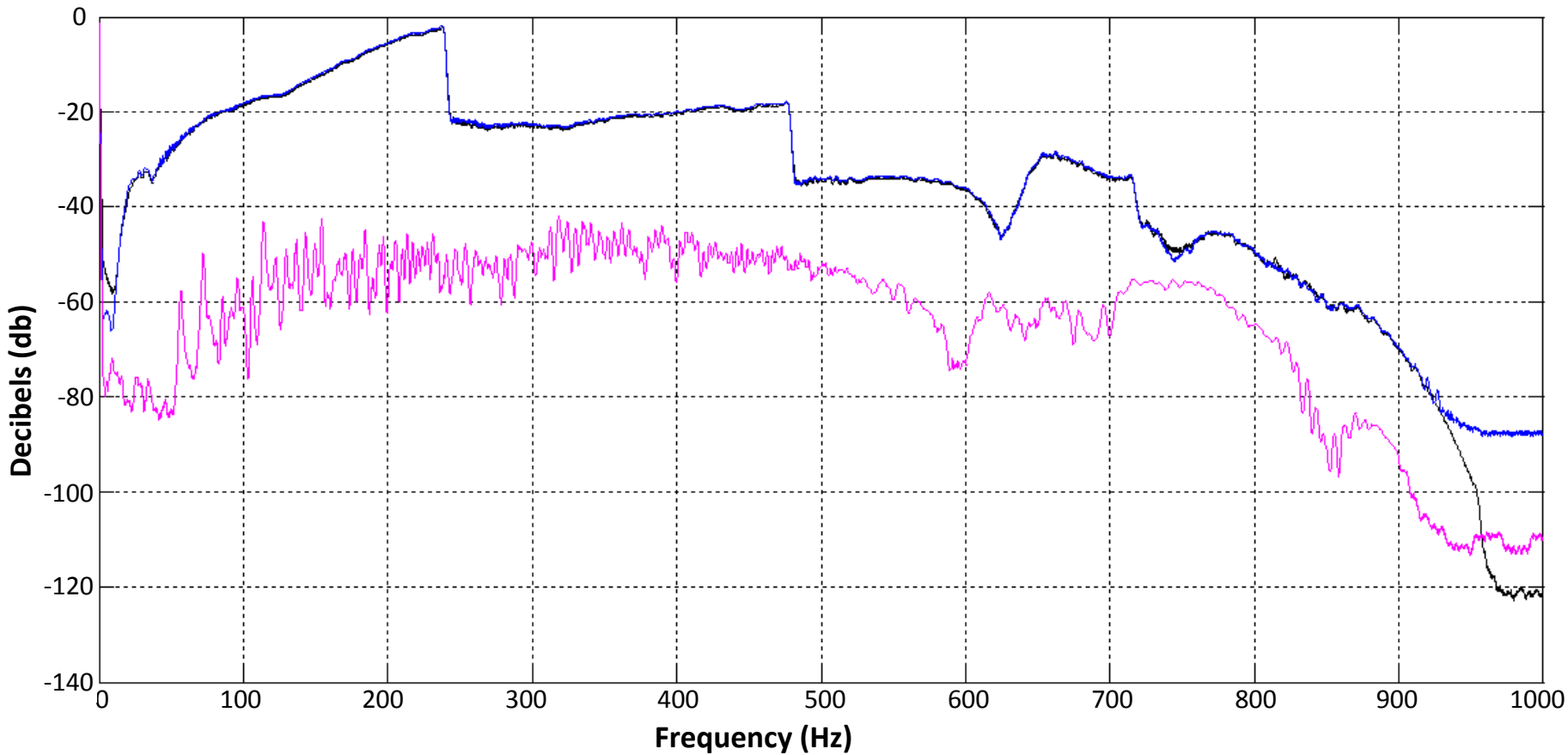


Black – Baseplate **Blue** – Combined components **Magenta** – Current component



[Time Domain](#) - Frequency Domain - [Gabor Domain](#)

H7 (Magenta)

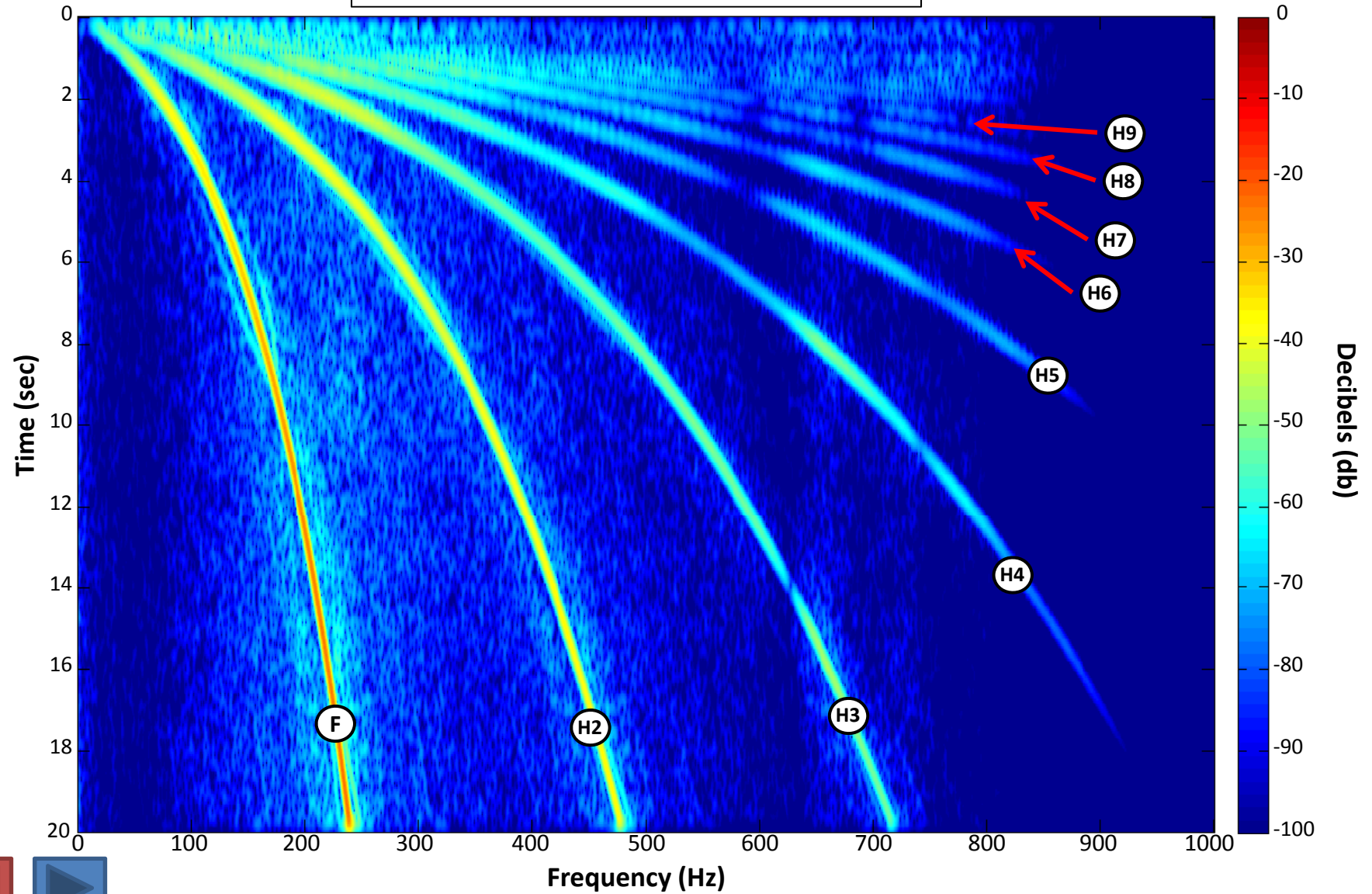


Black – Baseplate **Blue** – Combined components **Magenta** – Current component



[Time Domain](#) - Frequency Domain - [Gabor Domain](#)

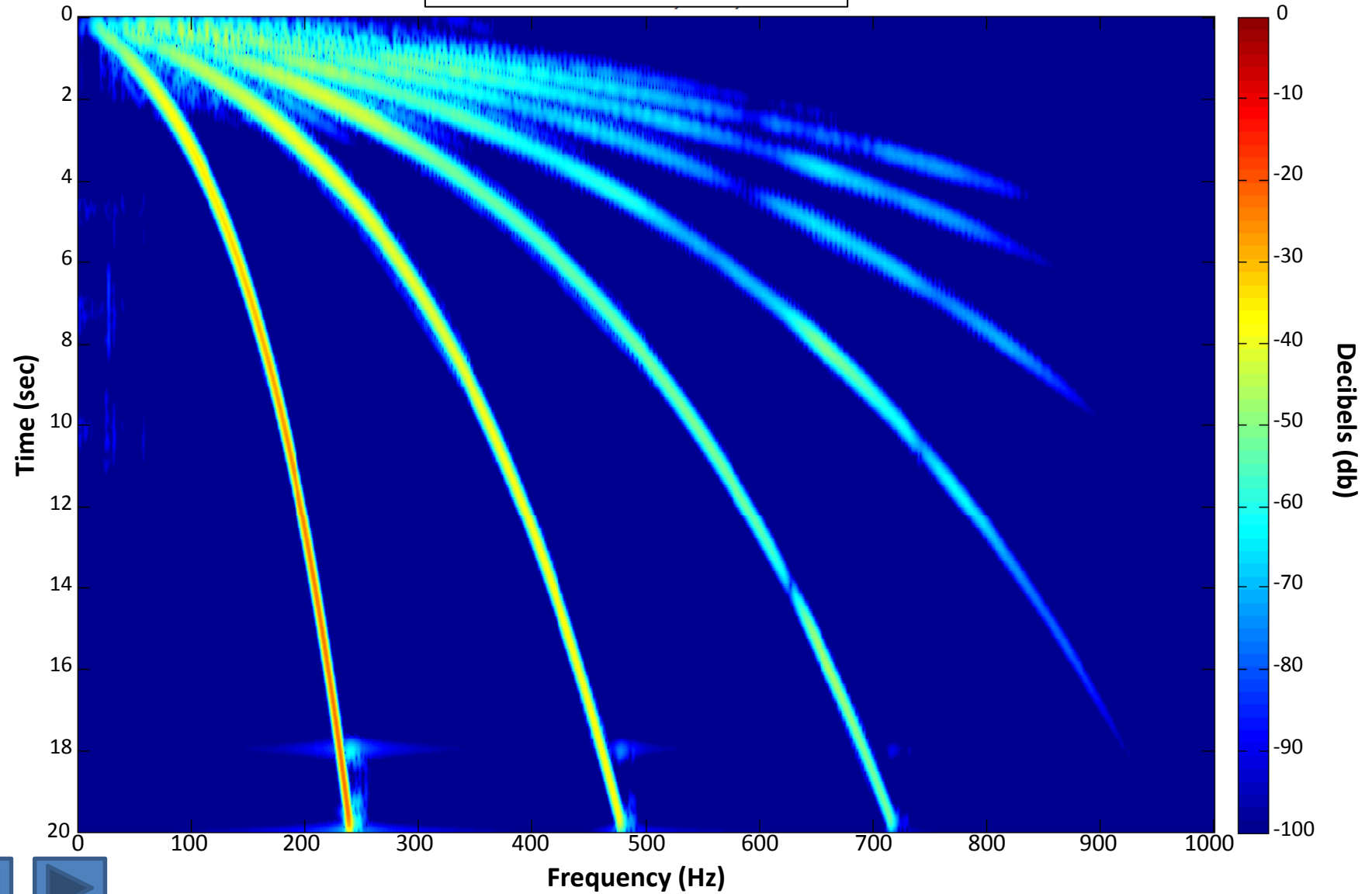
Sweep 3801 recorded at the baseplate



[Time Domain](#) - [Frequency Domain](#) - Gabor Domain

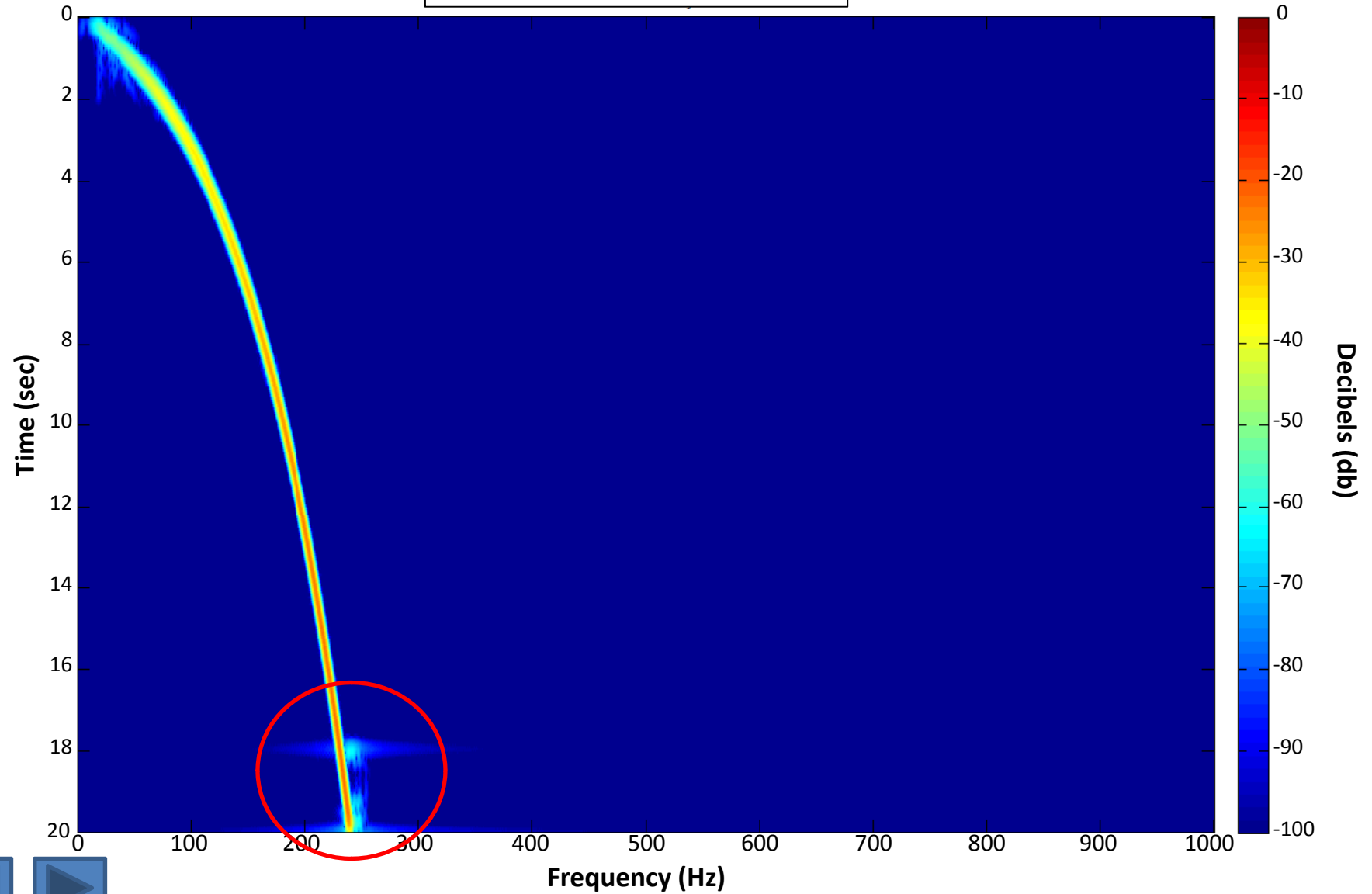
[Gabor Domain End](#)

Full Analysis



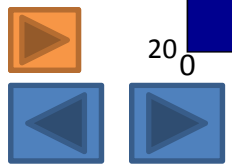
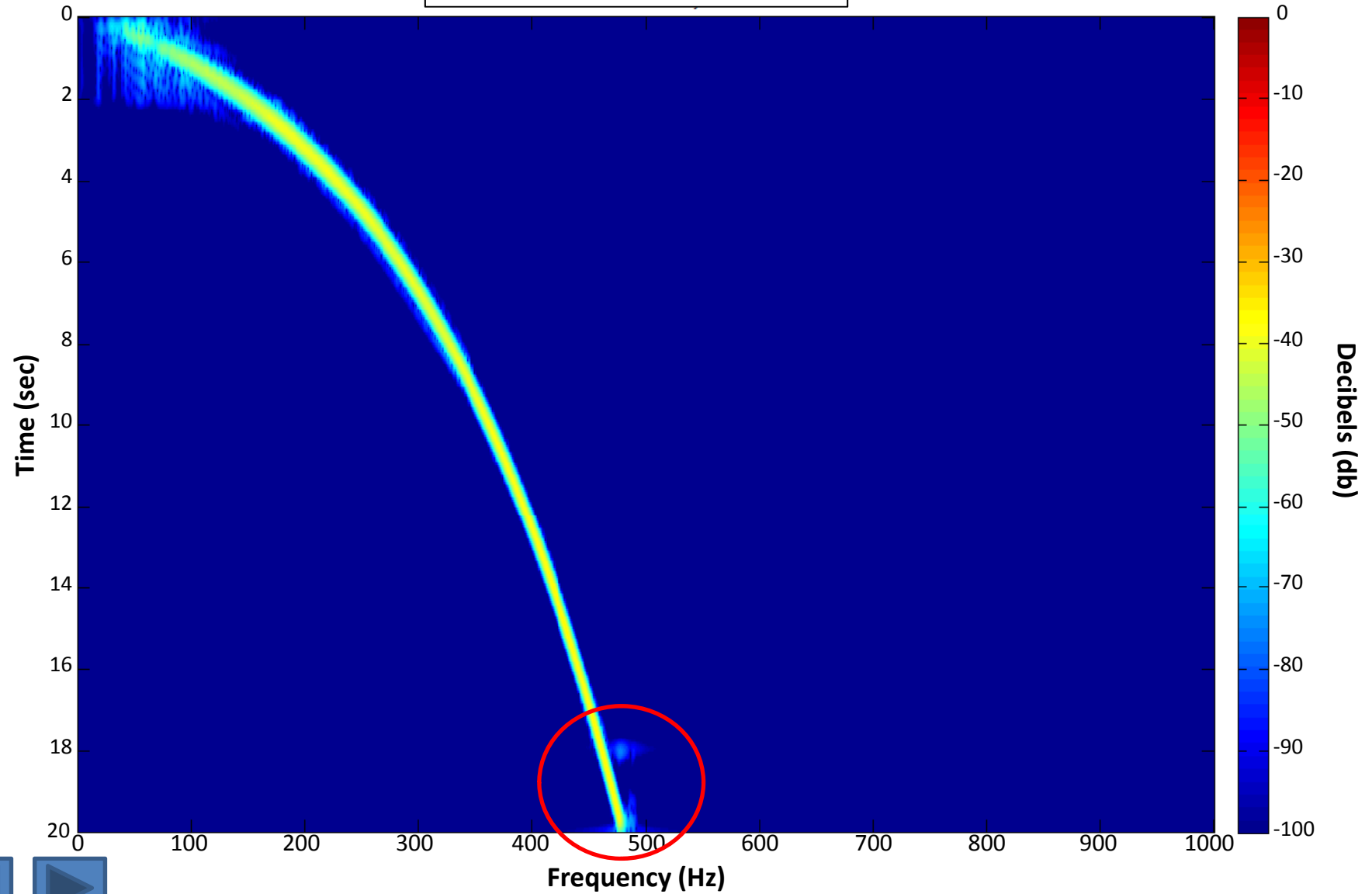
[Time Domain](#) - [Frequency Domain](#) - Gabor Domain

Fundamental



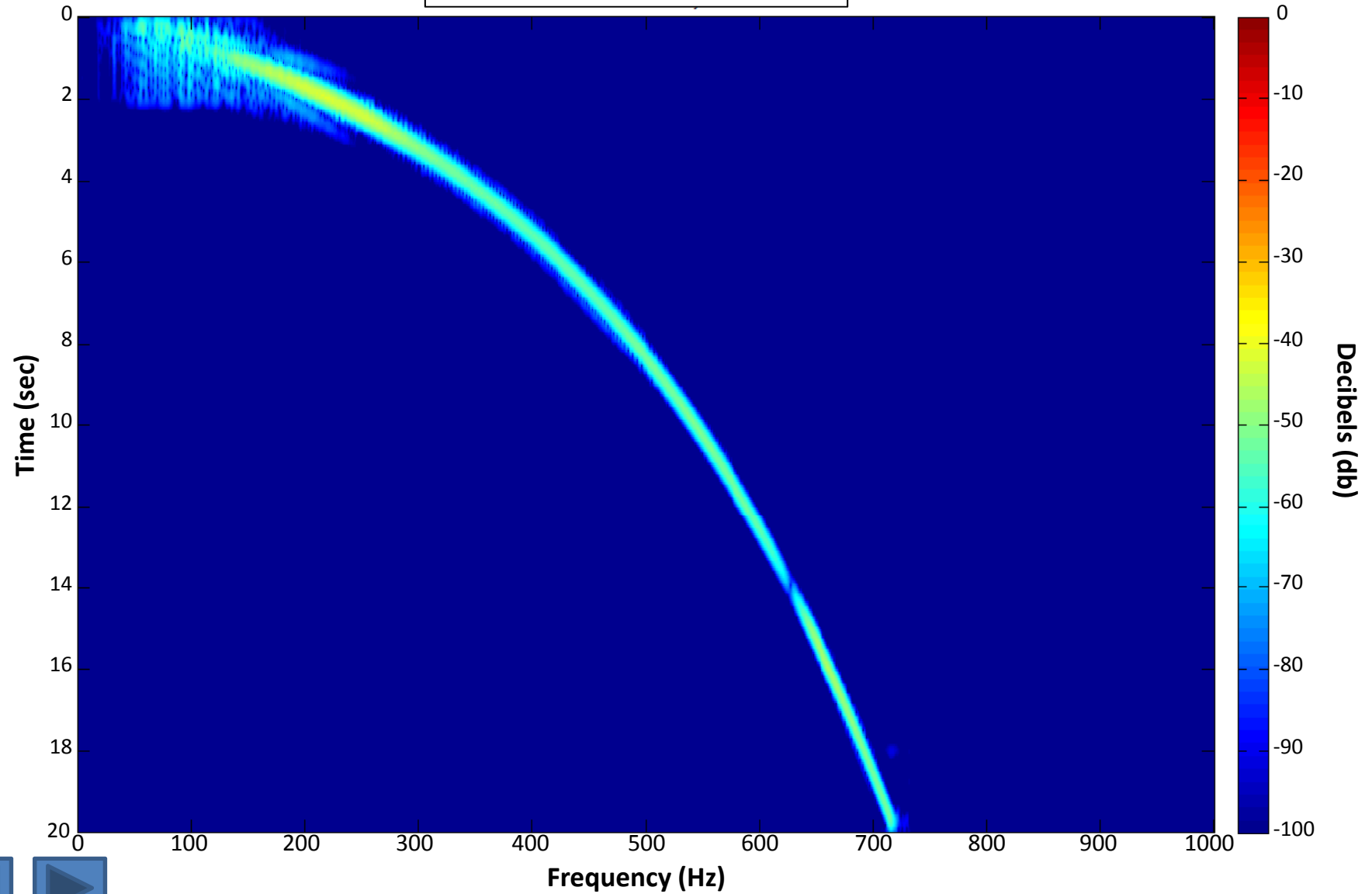
[Time Domain](#) - [Frequency Domain](#) - Gabor Domain

H2



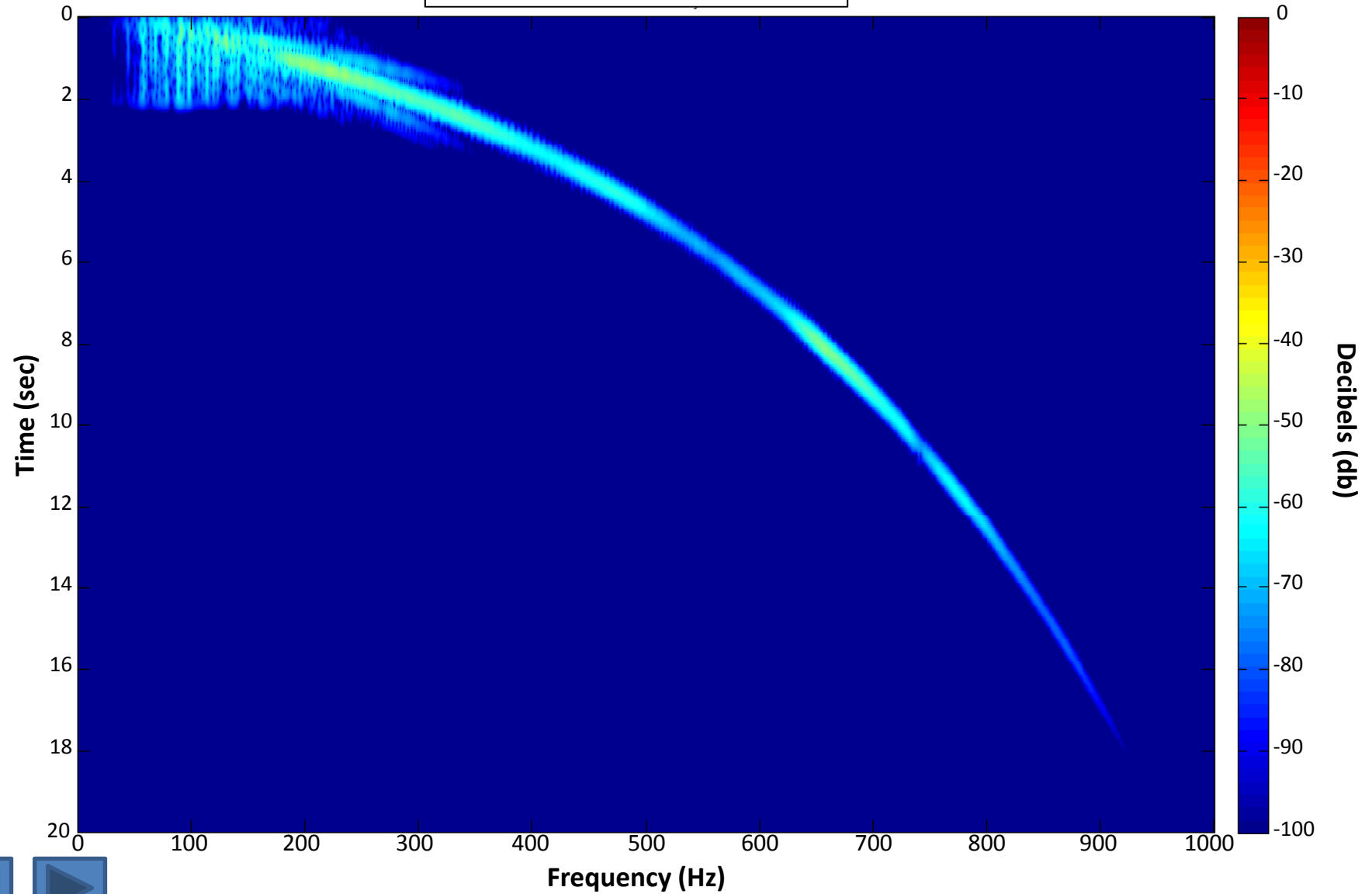
[Time Domain](#) - [Frequency Domain](#) - Gabor Domain

H3



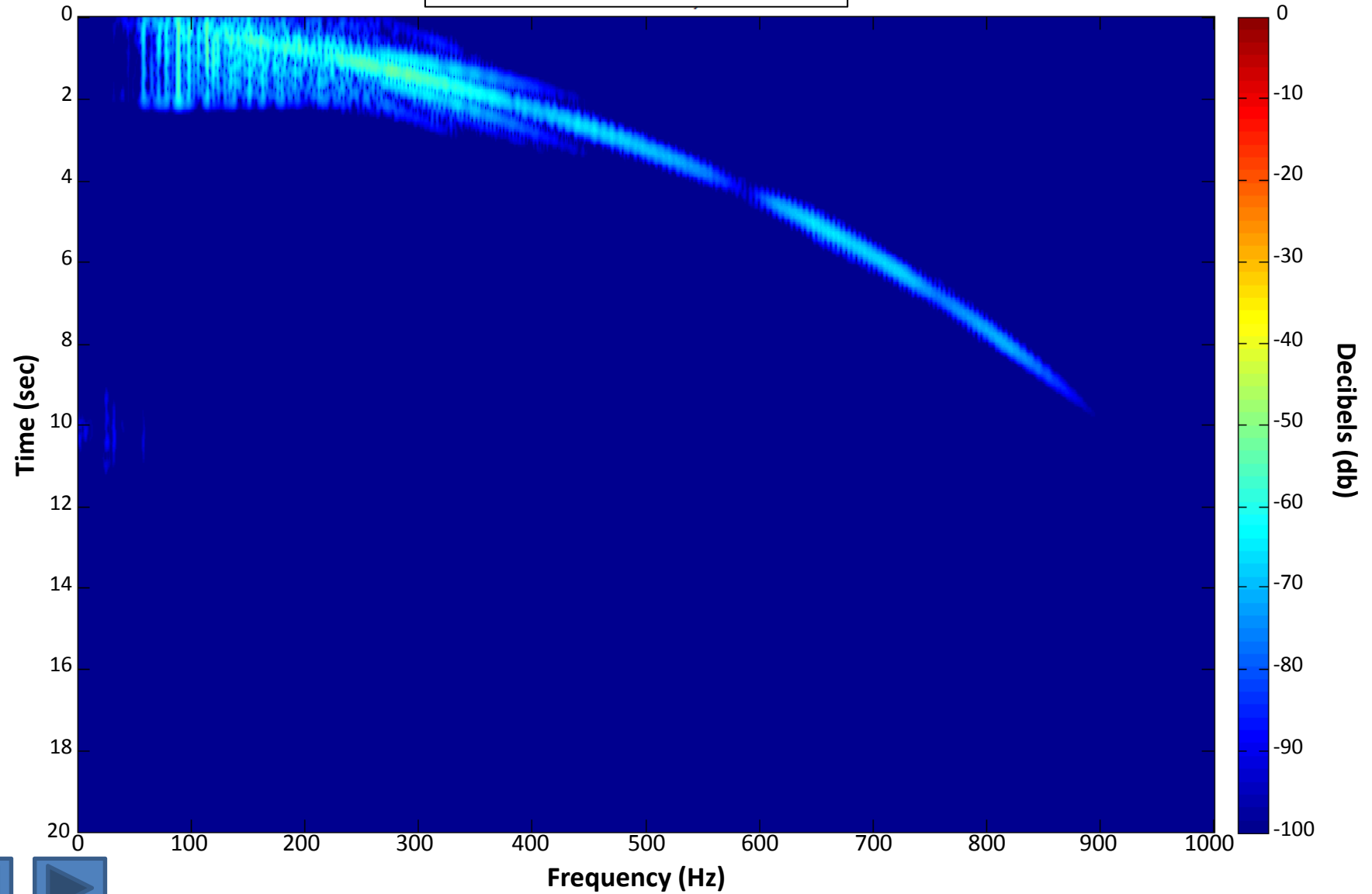
[Time Domain](#) - [Frequency Domain](#) - Gabor Domain

H4



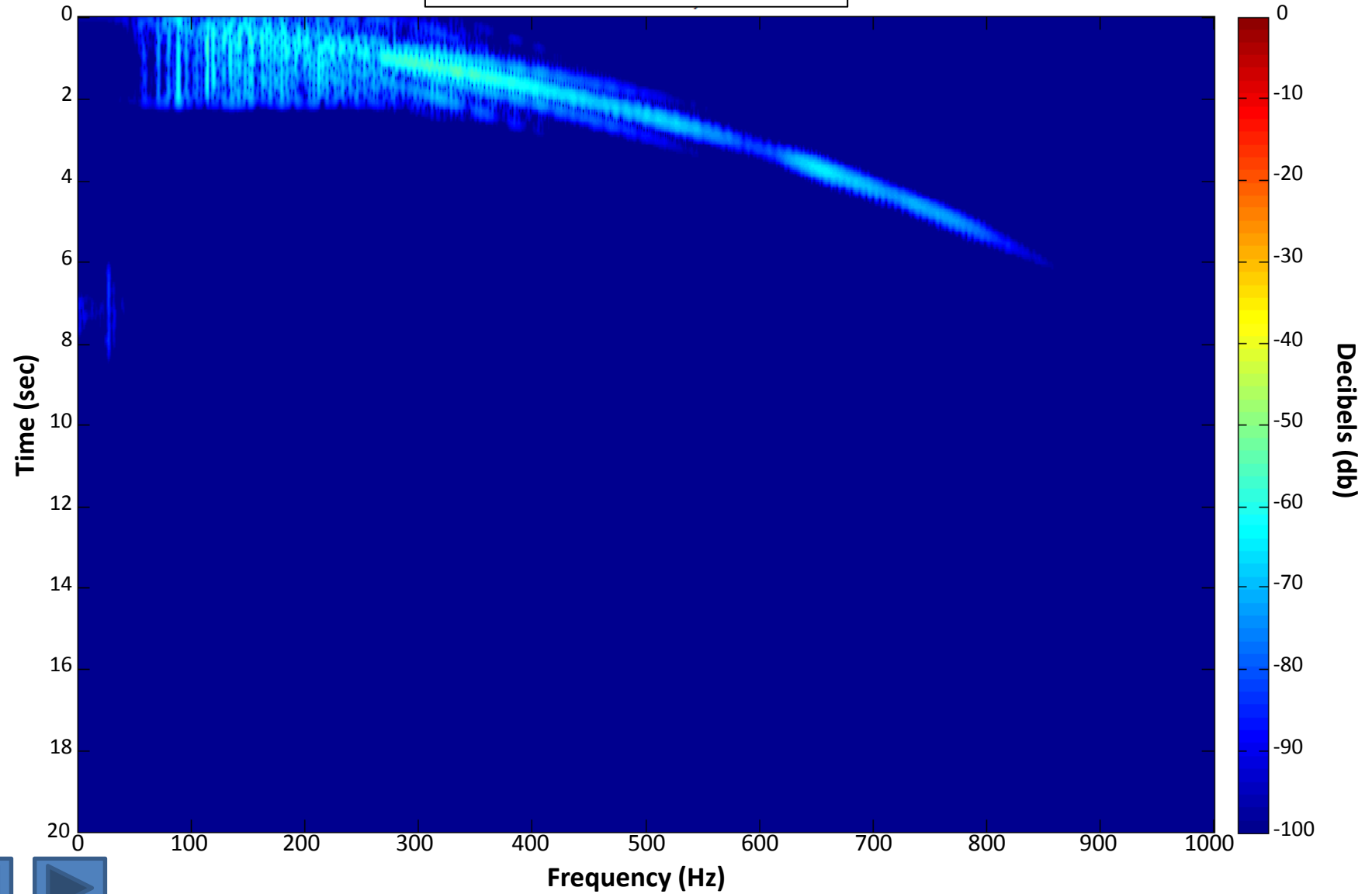
[Time Domain](#) - [Frequency Domain](#) - Gabor Domain

H5



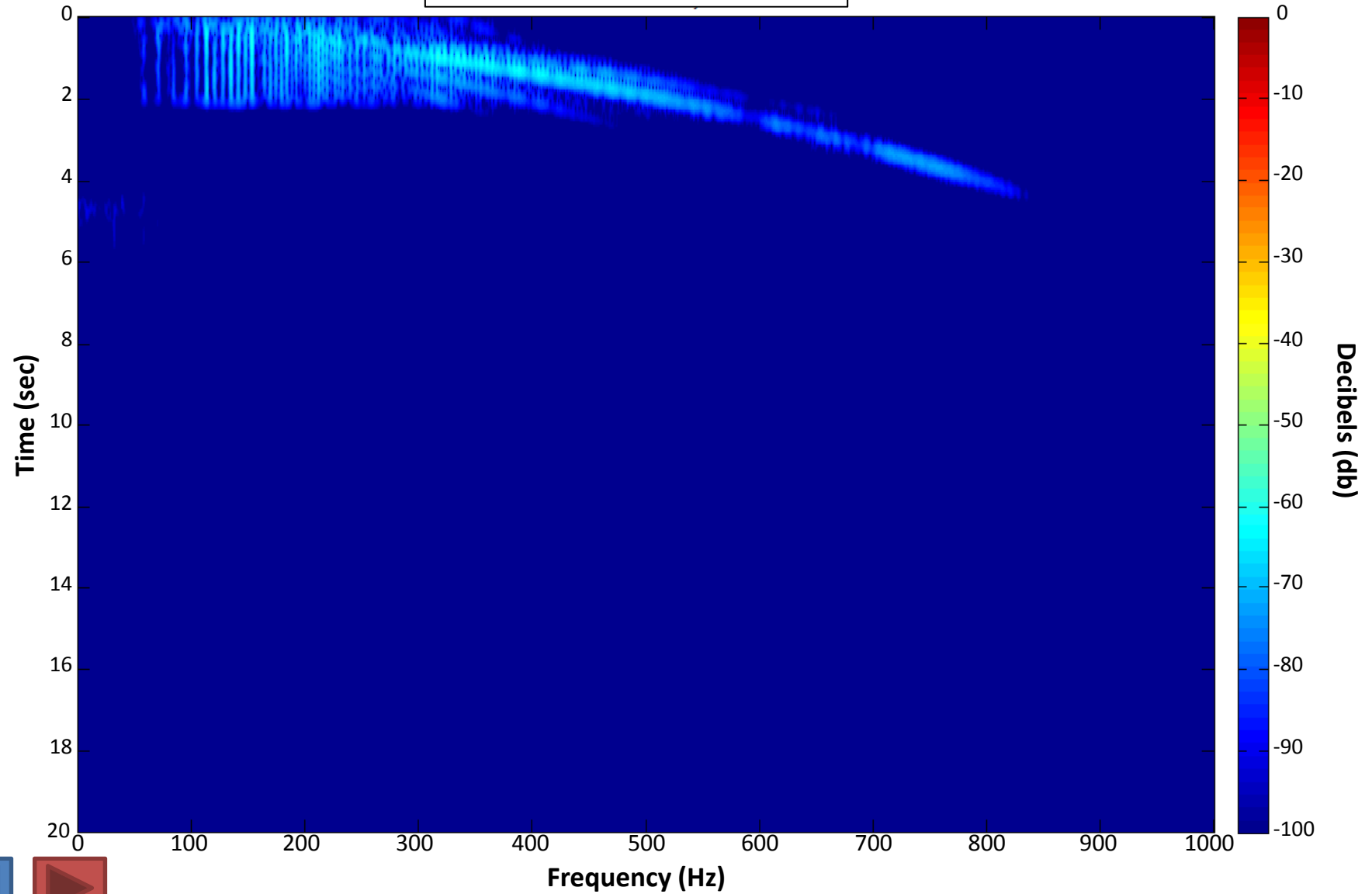
[Time Domain](#) - [Frequency Domain](#) - Gabor Domain

H6



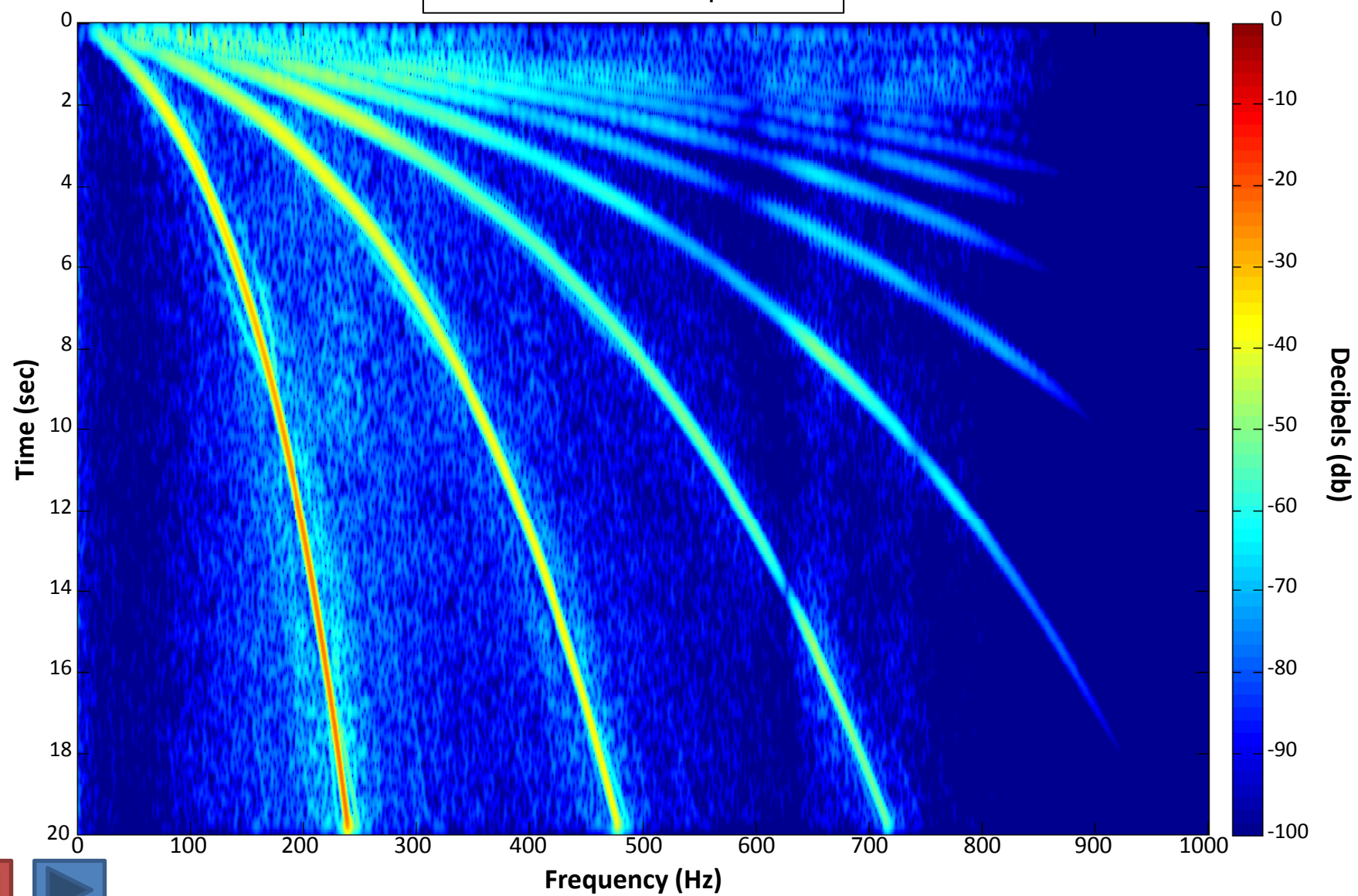
[Time Domain](#) - [Frequency Domain](#) - Gabor Domain

H7



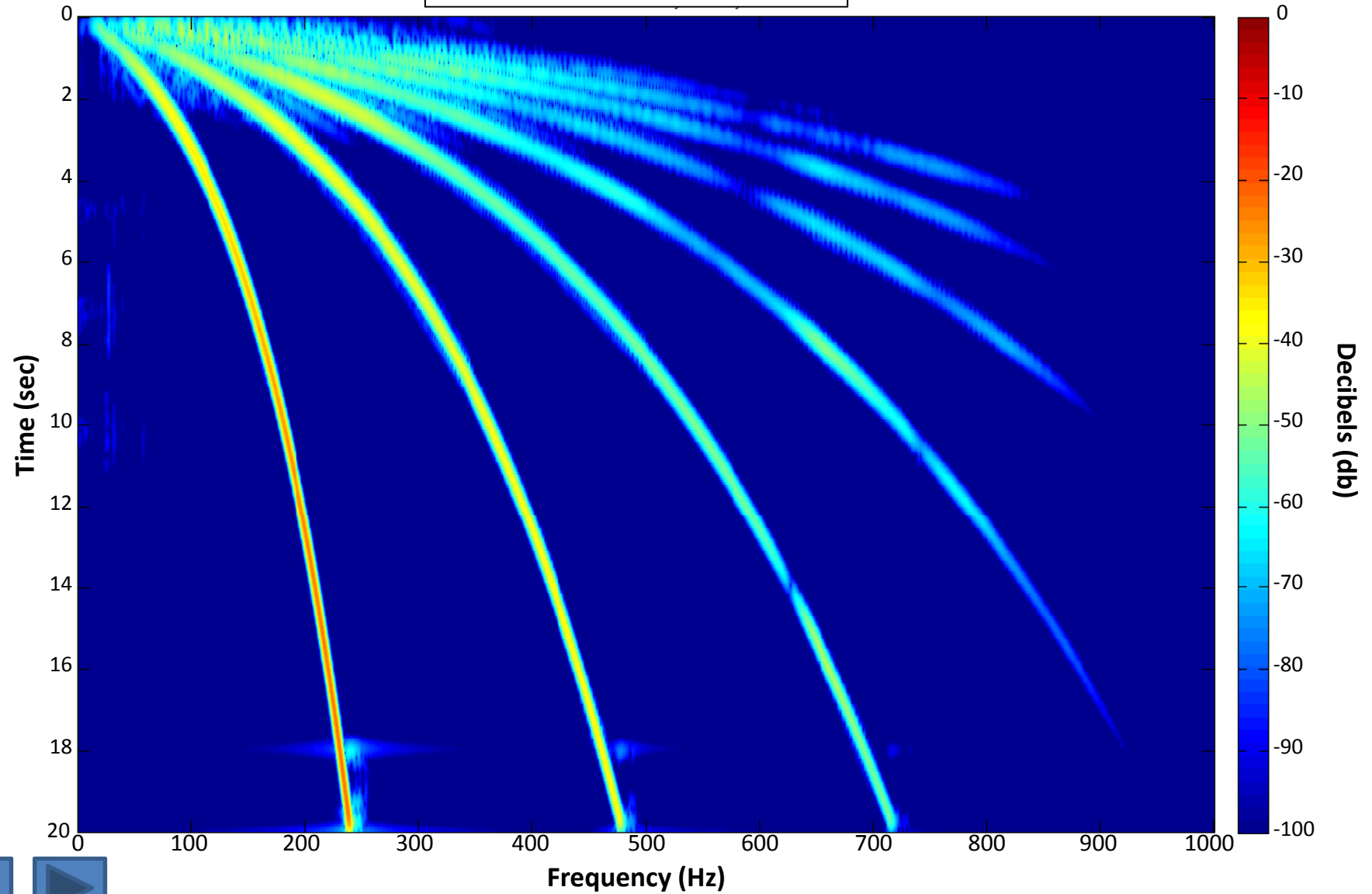
[Time Domain](#) - [Frequency Domain](#) - Gabor Domain

Base Plate – Sweep 3801



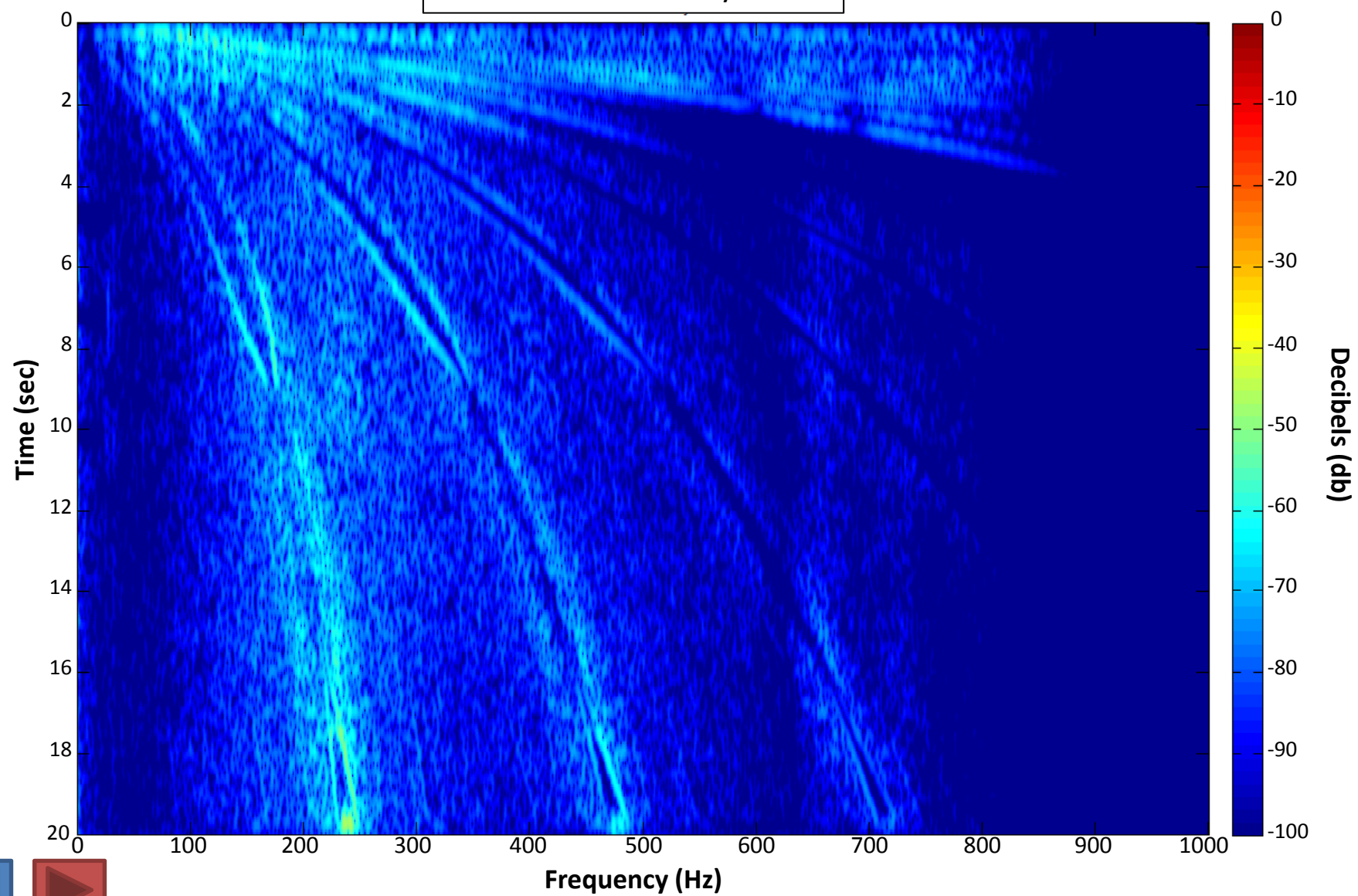
[Time Domain](#) - [Frequency Domain](#) - Gabor Domain

Full Analysis – Fund → H7



[Time Domain](#) - [Frequency Domain](#) - Gabor Domain

Error – BR - Analysis

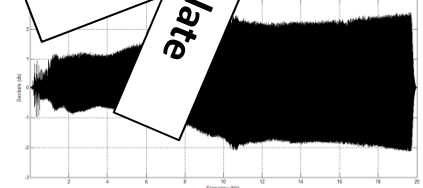
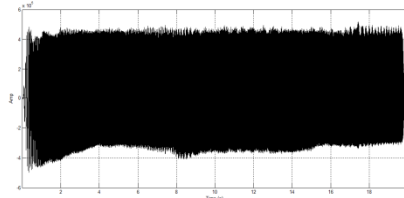
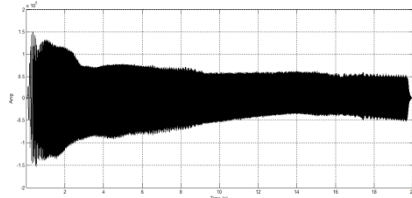


[Time Domain](#) - [Frequency Domain](#) - Gabor Domain

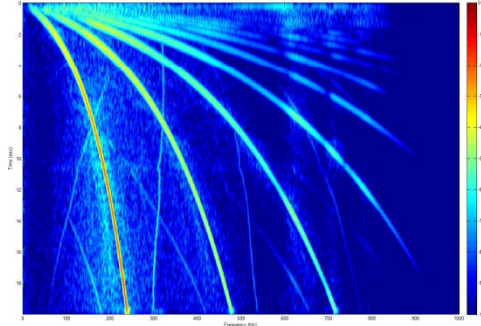
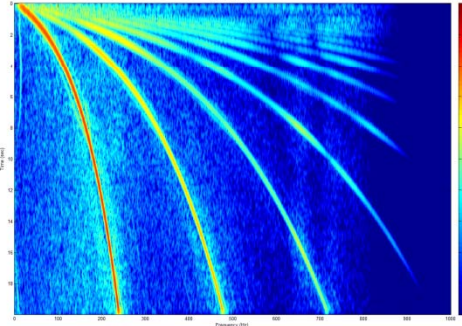
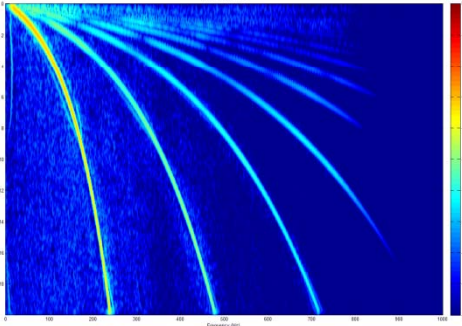
Ground Force

Reaction Mass

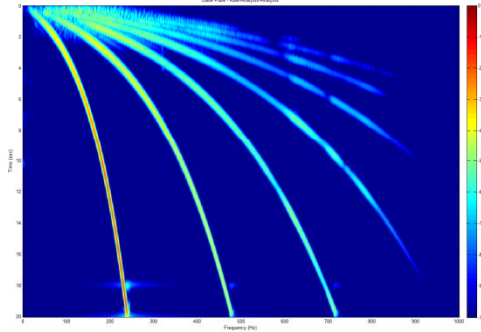
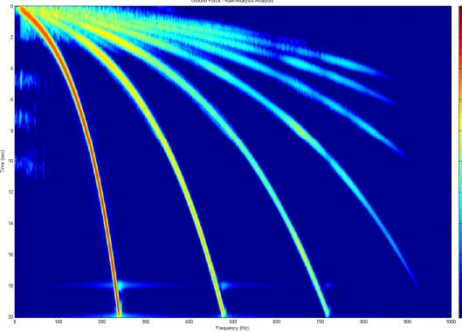
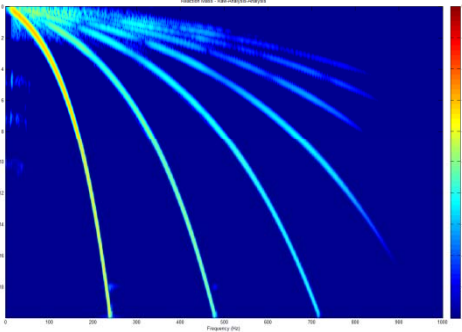
Noisy Baseplate



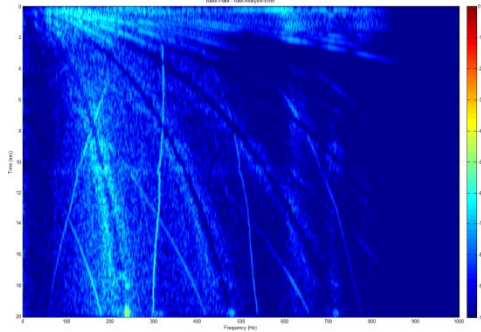
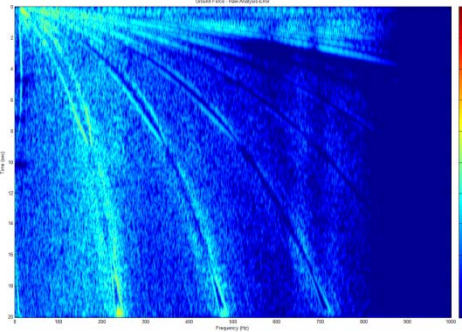
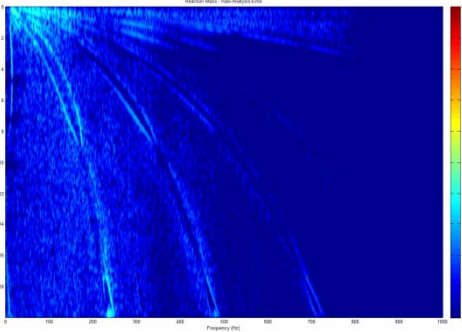
Raw Sweep



Analysis



Error

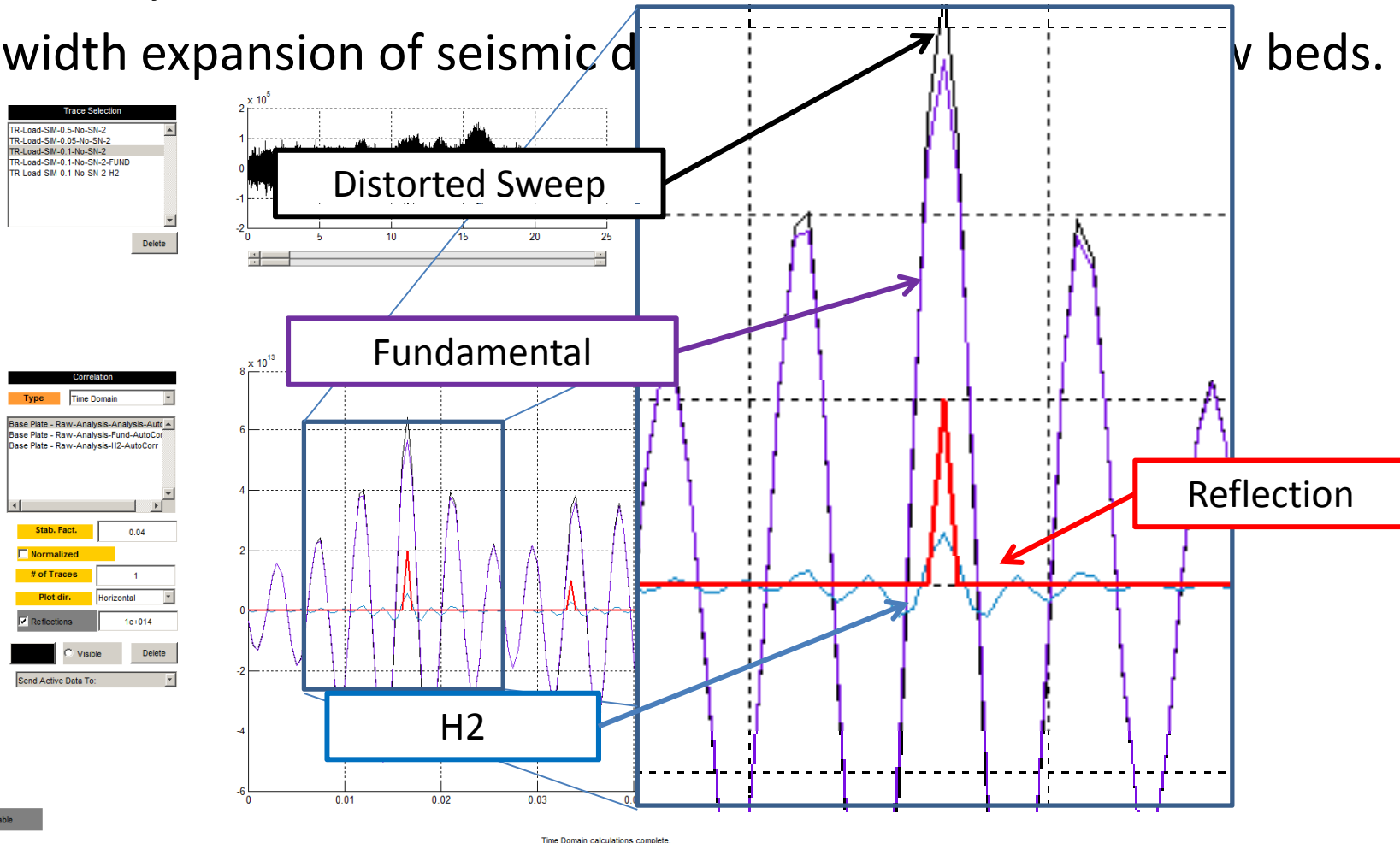


Summary

- Harmonics are generated in Vibroseis sweeps
 - non-linear mechanism in the vibrator hydraulics
 - poor baseplate –ground coupling
 - time-variance frequency dependant physical properties
- Harmonics to H9 are evident in the baseplate recorded sweep
 - H10 with good ground coupling?
- Harmonics to H4 are evident in traces
 - H5 with good ground coupling?
- Decomposition of a baseplate recorded sweep is successful to H7 using **Frequency dependant Gabor decomposition**.
 - Current algorithm

Future

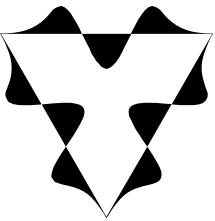
- Harmonic decomposition of the Hussar
- ~~Harmonic by harmonic attenuation~~
- Bandwidth expansion of seismic data from 10 to 20 Hz beds.





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