Follow up Results from NM-III Field-test

Scenario

- Probe melting into the Ice at Antarctica
- Driving back in a melting channel
  - Up to 15m into the ice
  - The melting channel is filled with water
  - Different signals were sent to analyze the depth
    - Barker
    - Chirp
    - Sinus Burst

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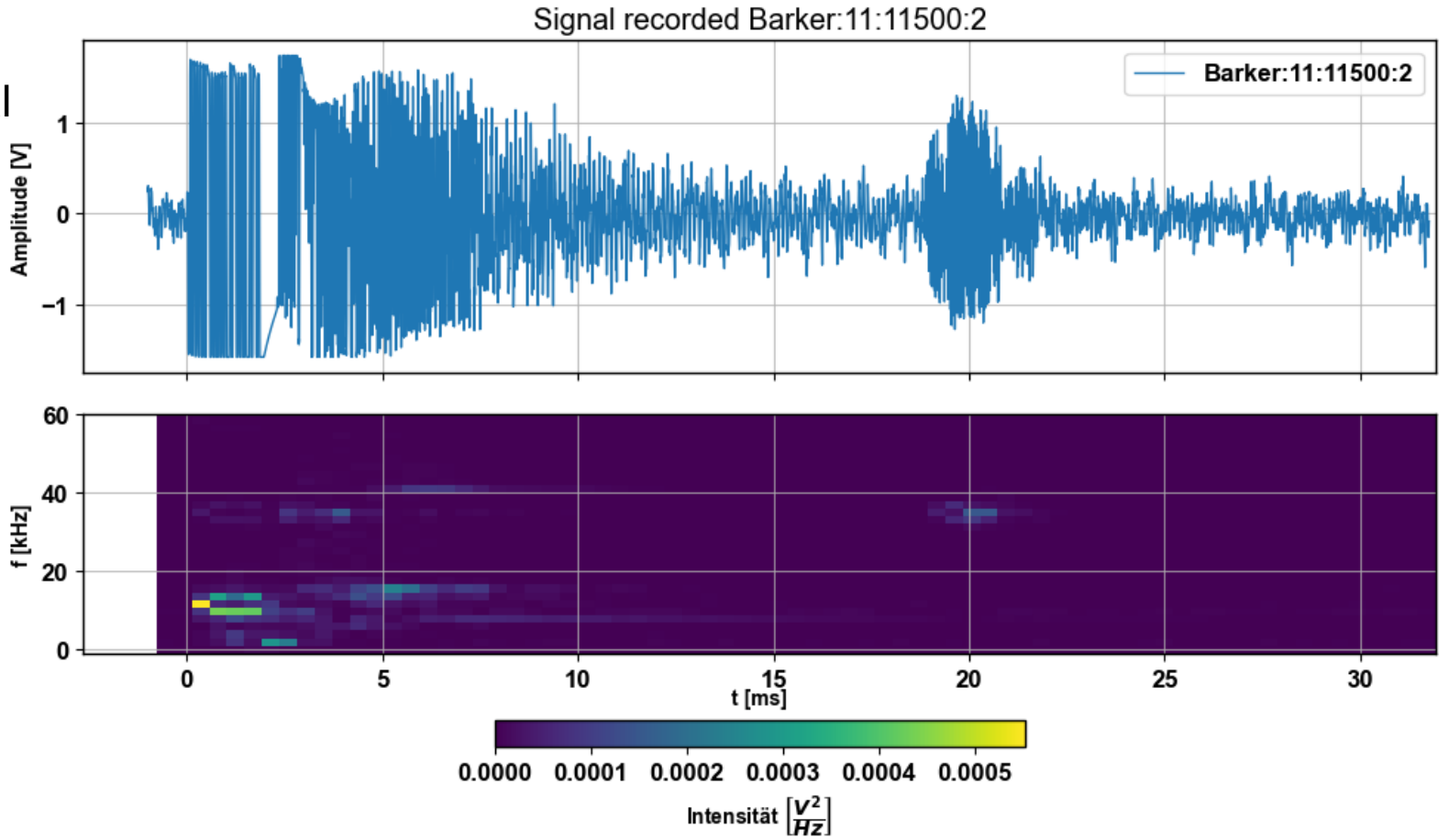
What were the results of the field test

Able to see the reflection of the ice

- Able to see the reflection of the ice
- Was not the frequency of the send signal
- Example of a Barker:11:11500:2
  - Reflection frequency around 35 kHz



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Goal

- Understanding why the reflection does not contain low frequency components
- Is there a channel effect?
- Is it possible to get a more accurate measurement?
- Using the TVR und OCRR to improve the signal

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Signal Processing

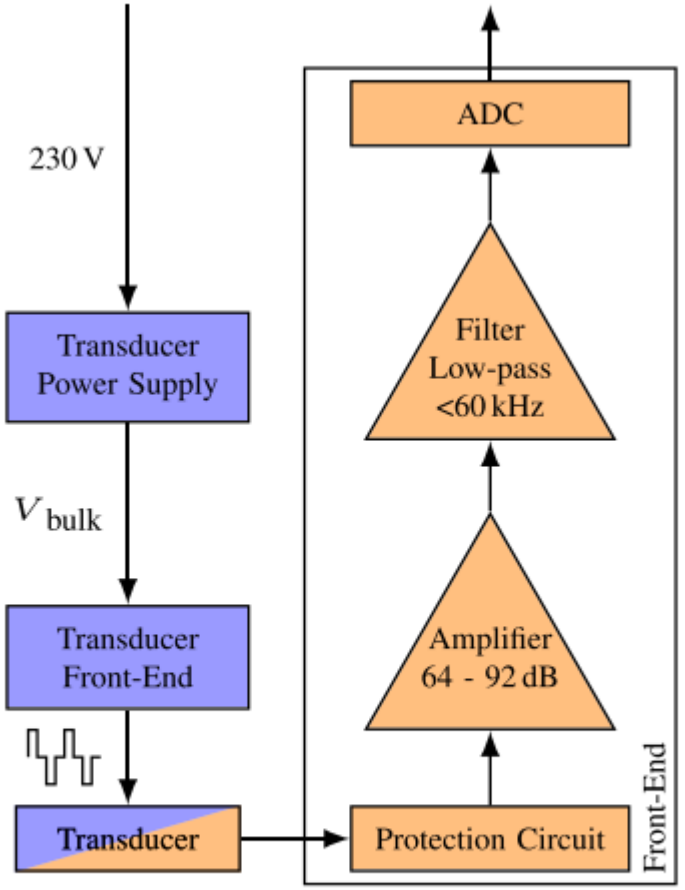
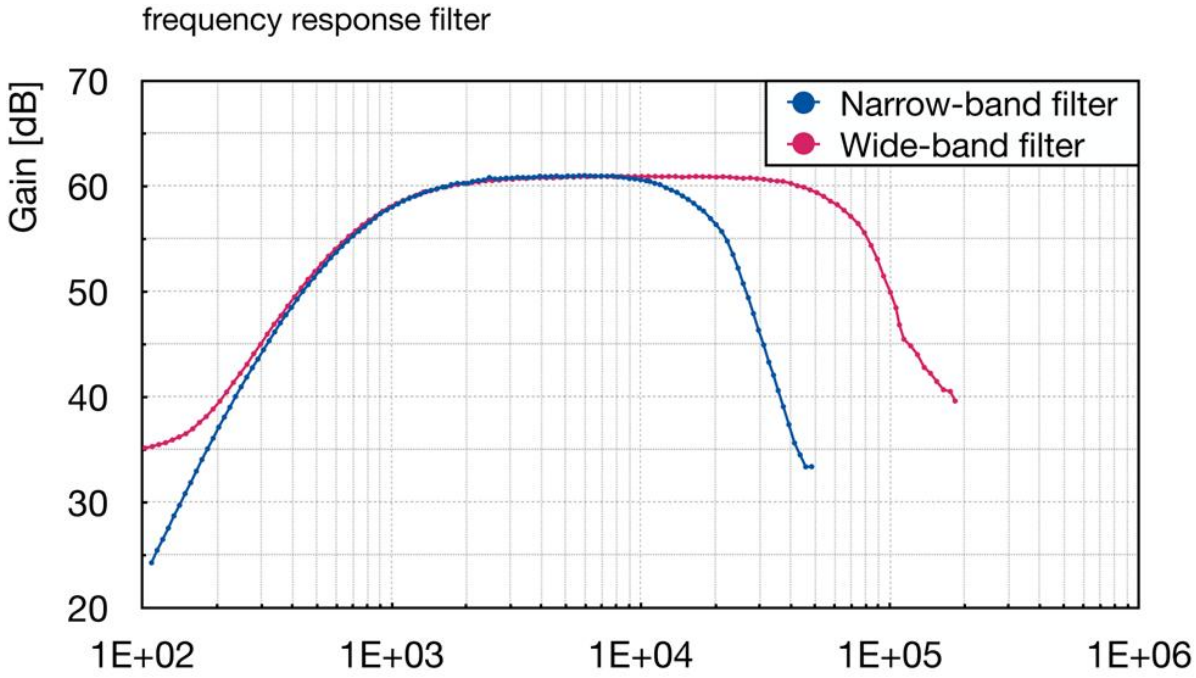


Fig. 17. Block diagram of the sonar system from signal generation to signal digitization. The emitter path is shown in purple and the receiver path in orange.

https://ieeexplore.ieee.org/document/10411117

- Transducer approximates waveform through rectangular pulses
- 2 Band filter. Only in the Wide-band filter able to see the reflection



https://www.cambridge.org/core/journals/annals-of-glaciology/article/autonomous-pinger-unit-of-the-acoustic-navigation-network-in-enexrange-an-autonomous-inice-melting-probe-with-acoustic-instrumentation/9DC86C102EDFBC28FADC8B24B219A826

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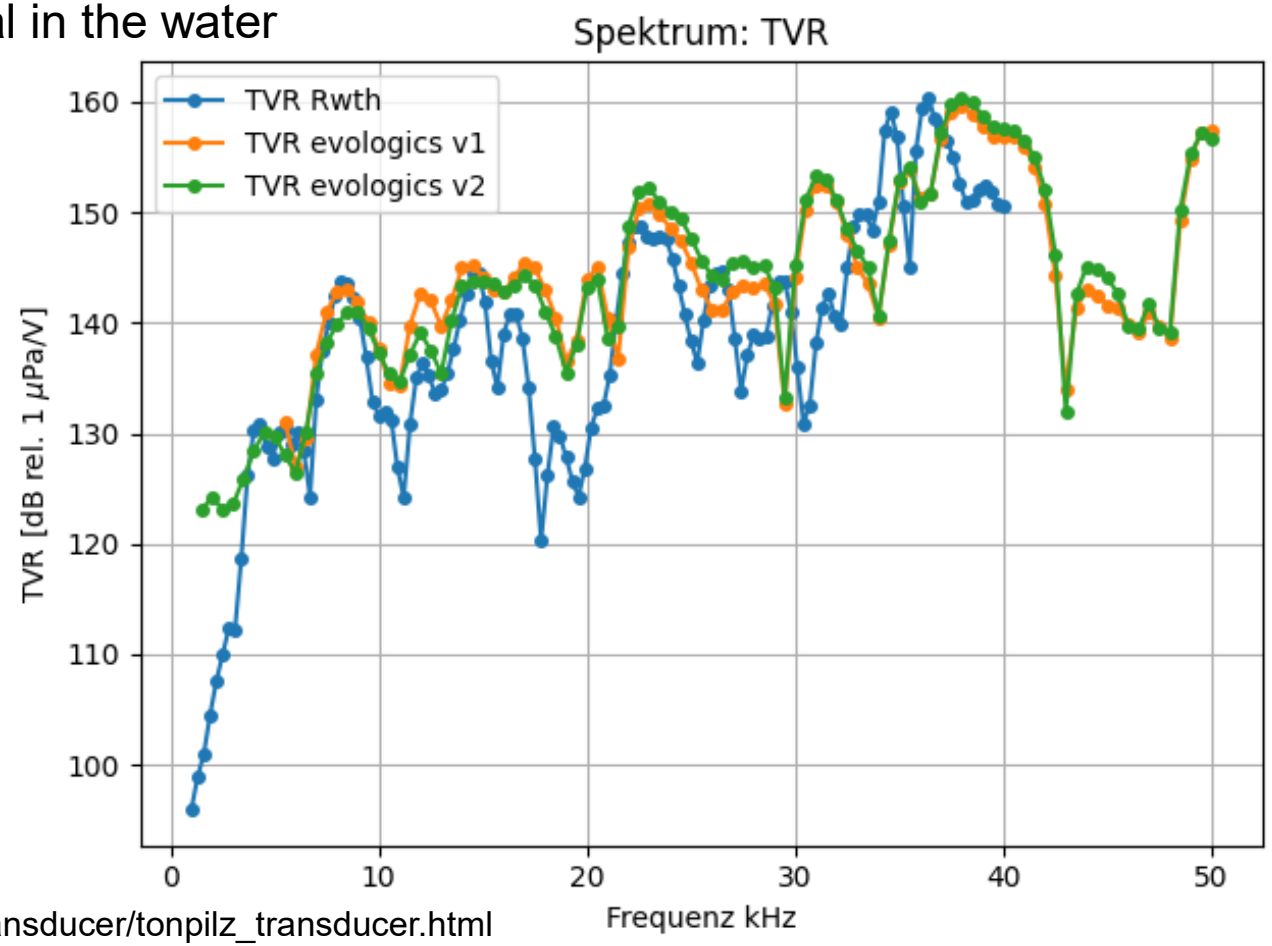
Using the TVR

- TVR as a Value to calculate the pressure wave in the water
- Correcting the outgoing signal to find the actual signal in the water
- $TVR = 20 \cdot \log_{10} \frac{p}{V} \Leftrightarrow p = 10^{\frac{TVR}{20}} \cdot V$ [1]
- Calculate the FFT of the Signal times $10^{\frac{TVR_{\{frequency\}}}{20}}$
- Different TVR
  - RWTH
  - two from Evologics



[1] https://doc.comsol.com/5.6/doc/com.comsol.help.models.aco.tonpilz_transducer/tonpilz_transducer.html

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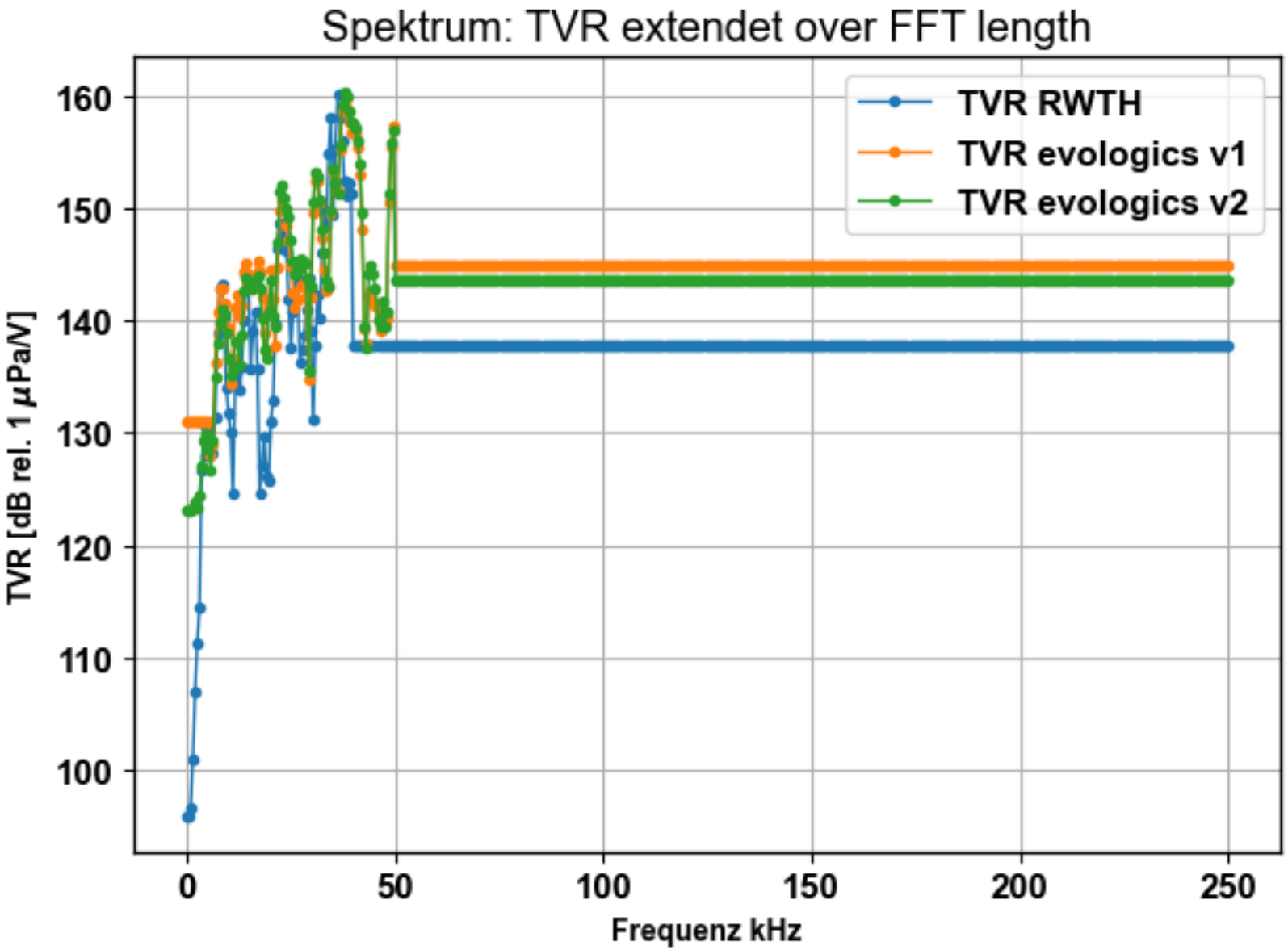
- TVR extended to match the FFT length using the mean of the TVR



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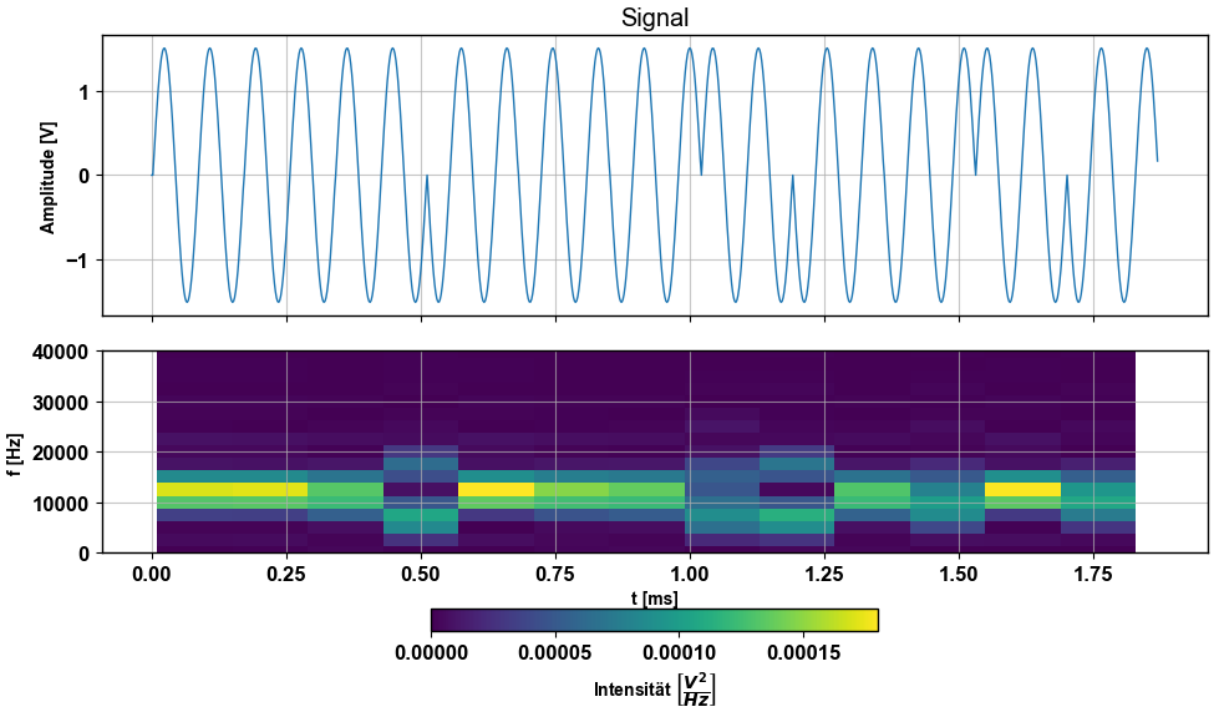
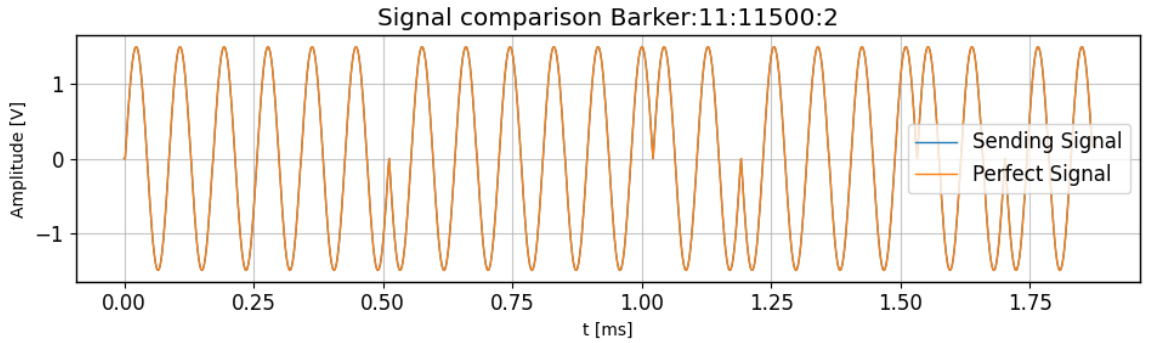
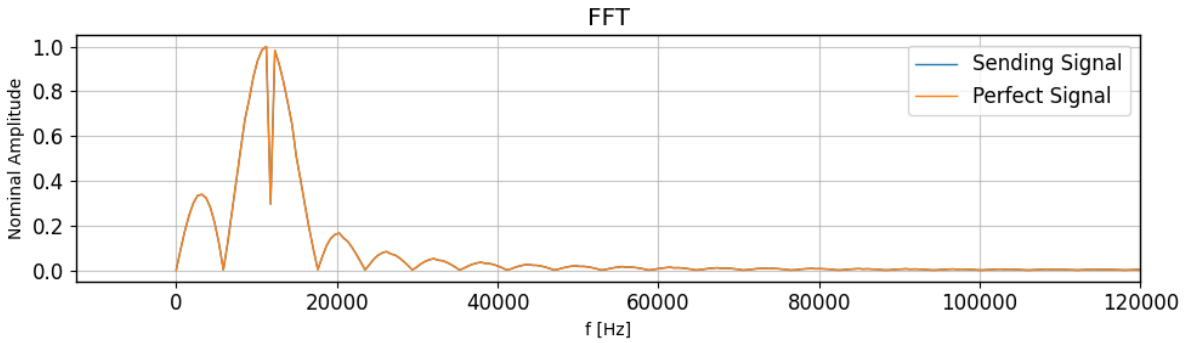
Perfect signal Barker:11:11500:2







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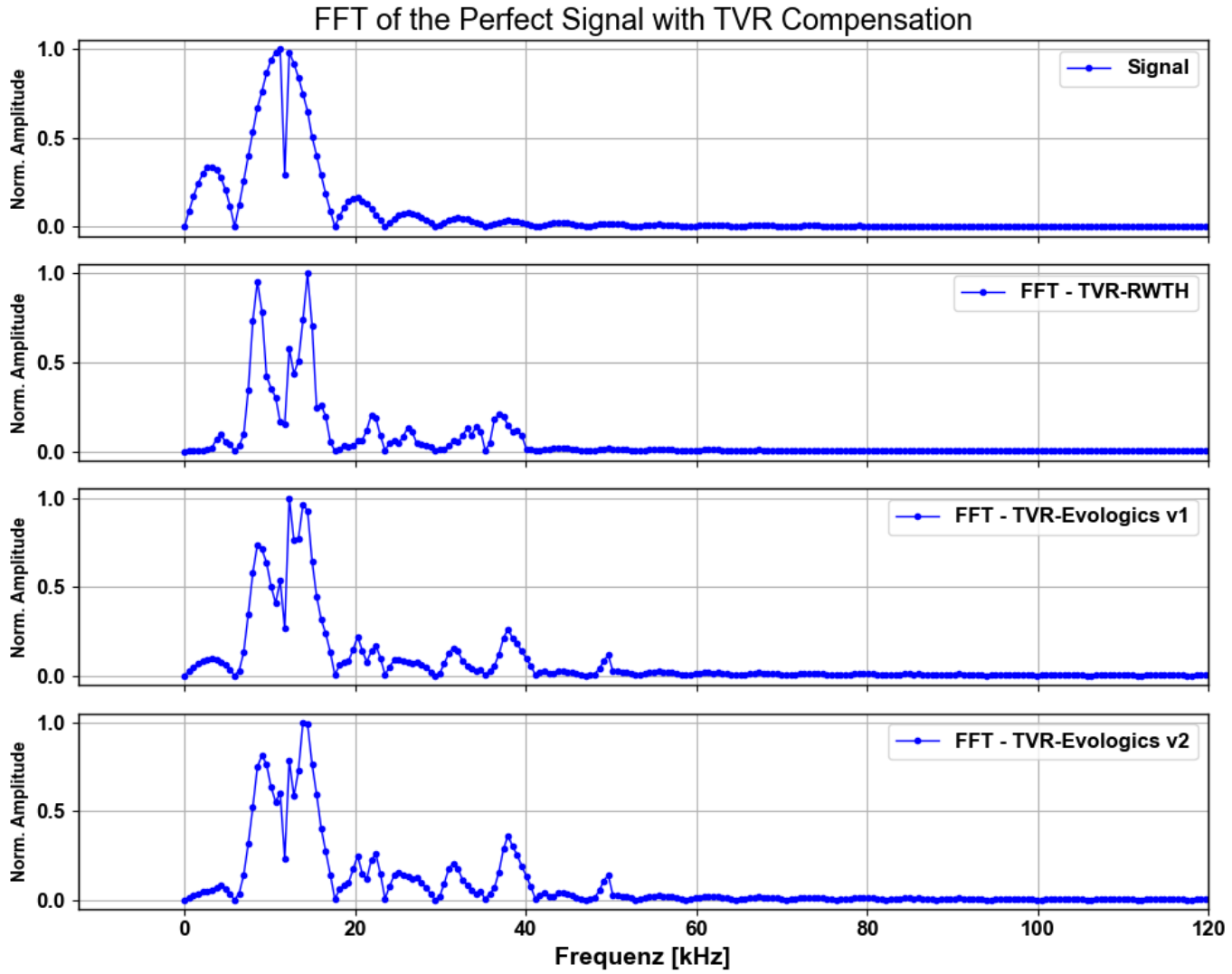
FFT comparisons after TVR calculation with the perfect Signal



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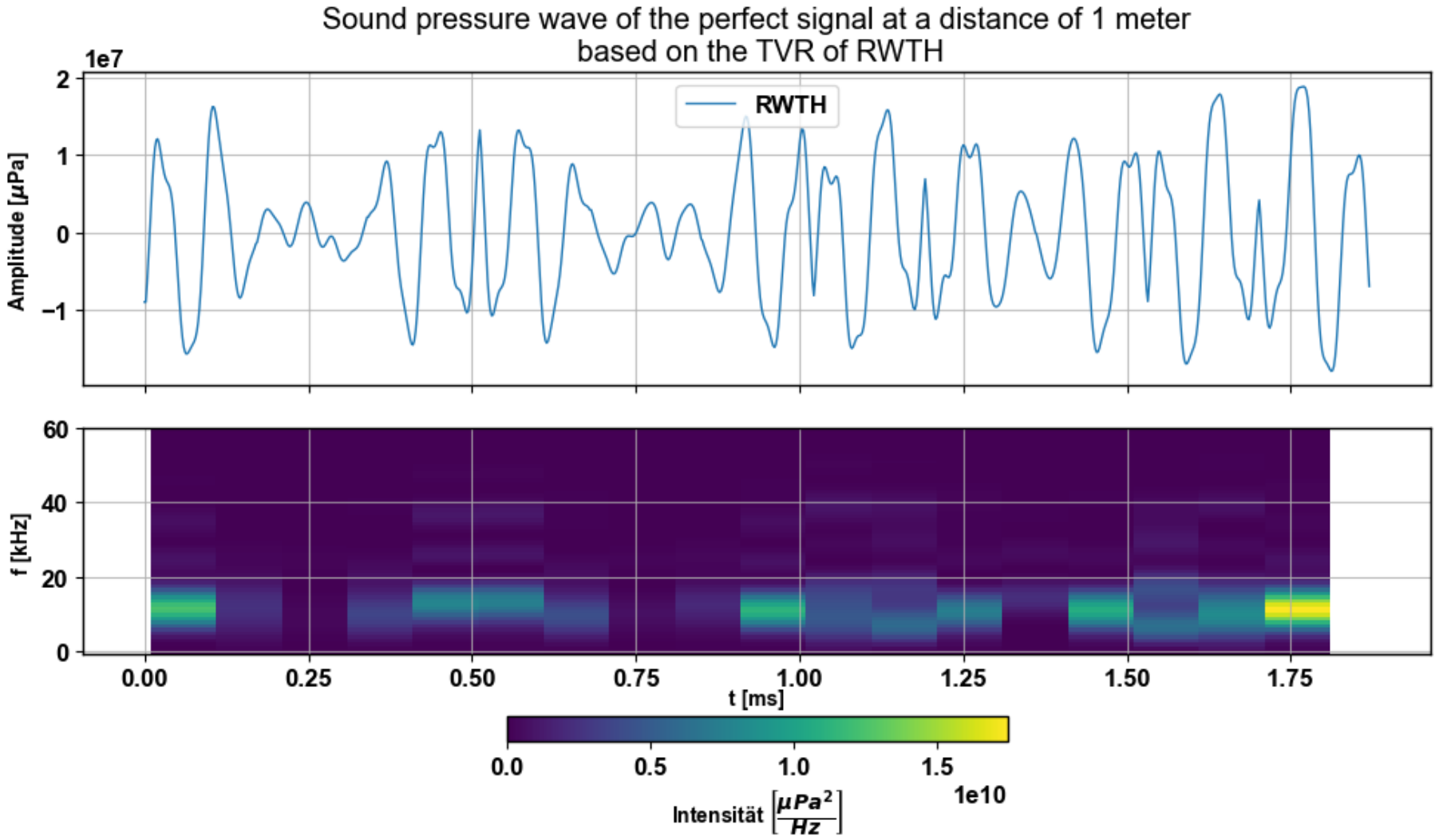
Resulting pressure wave at 1m distance with RWTH TVR



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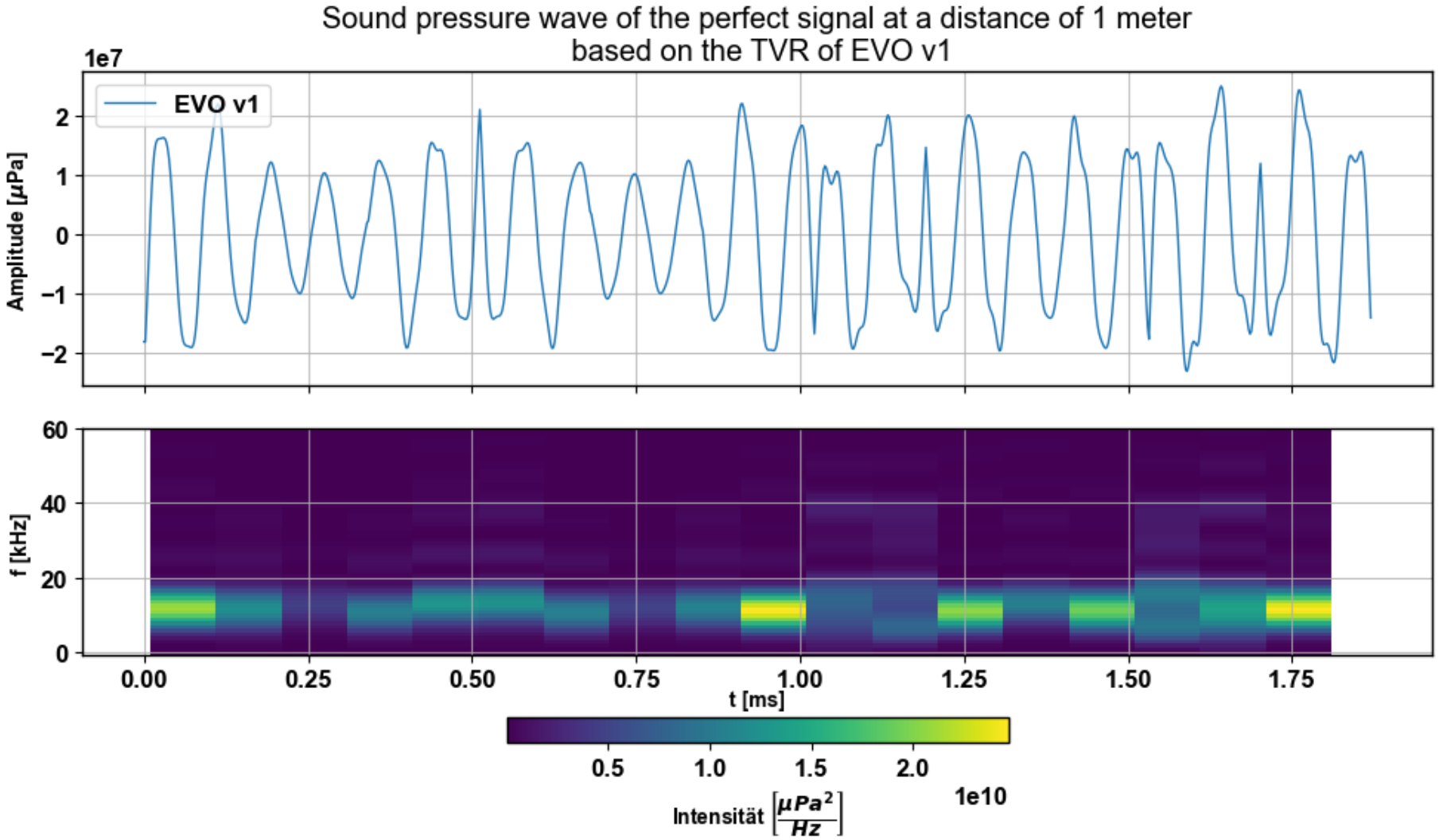
Resulting pressure wave at 1m distance with Evologics TVR v1



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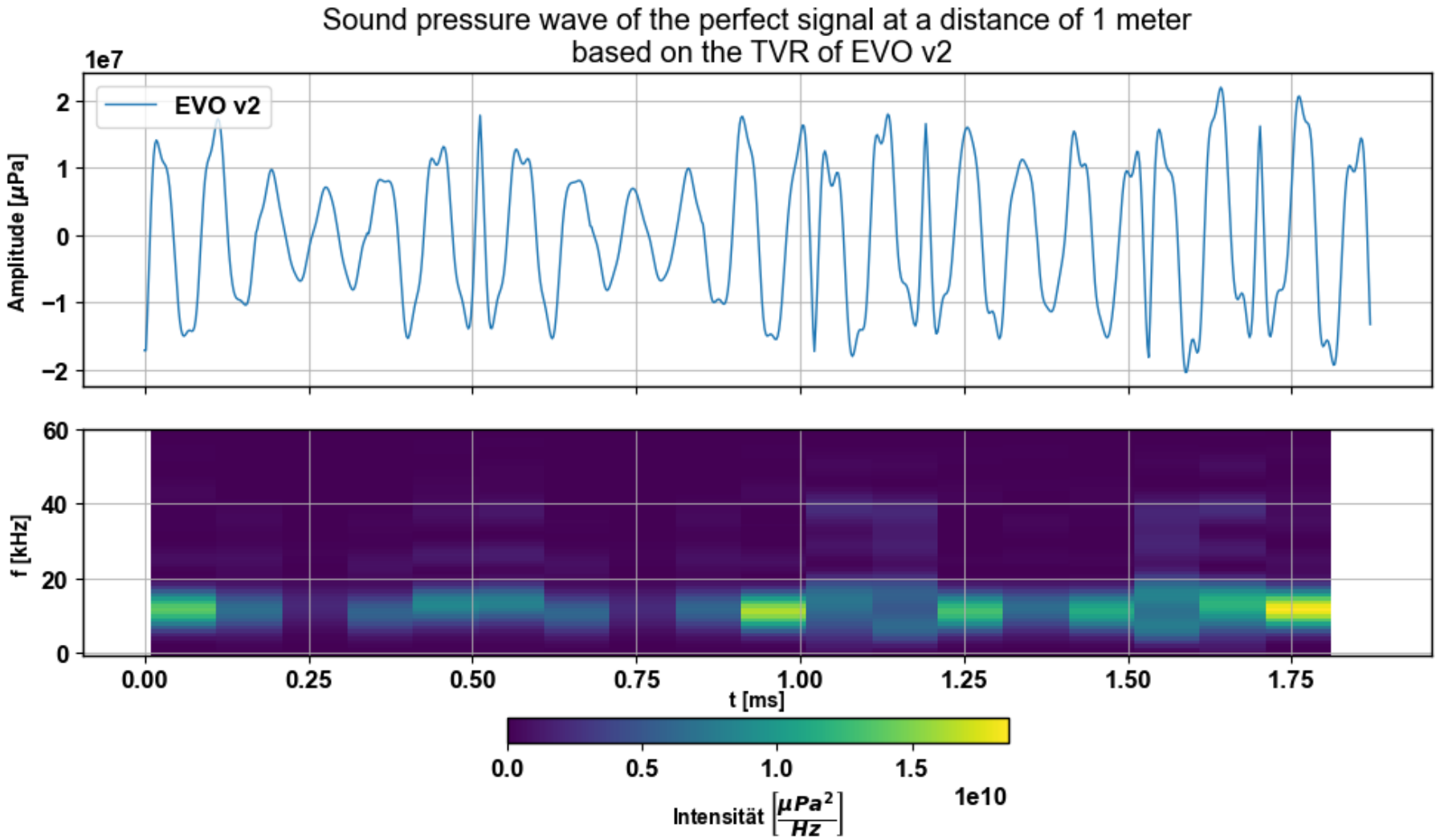
Resulting pressure wave at 1m distance with Evologics TVR v2



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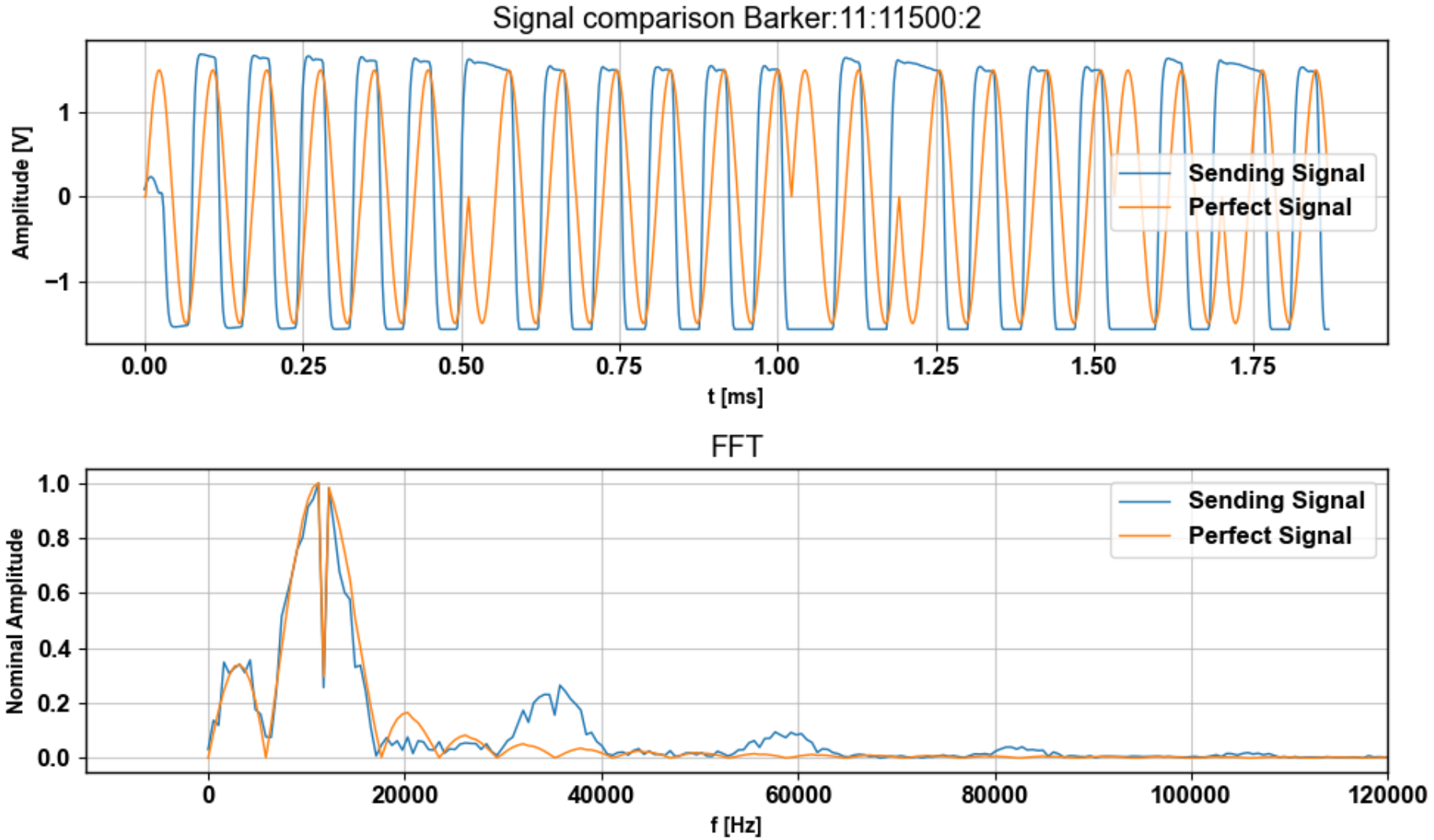
Comparison between the two signals



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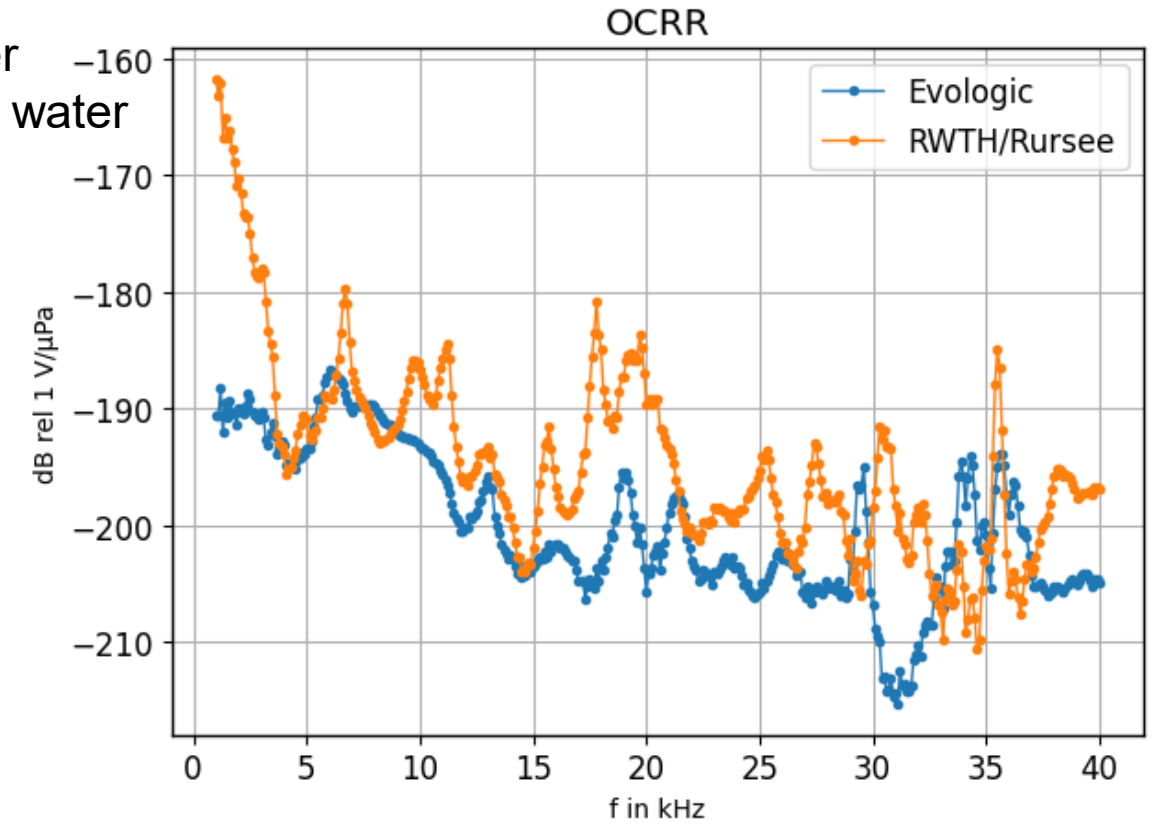
OCRR

- Open Circuit Receiving Response
- OCRR as a value to calculate the pressure wave in the water
- Correcting the input signal to find the actual waveform in the water
- $OCRR = 20 \cdot \log_{10} \frac{V}{p} \Leftrightarrow p = \frac{V}{10^{\frac{OCRR}{20}}}$ [3]
- Calculate the FFT of the Signal divided by $10^{\frac{OCRR_{\{frequency\}}}{20}}$
- Different OCRR
  - RWTH
  - Evologics



[3] https://upcommons.upc.edu/bitstream/handle/2117/129596/157-1380-2-PB.pdf

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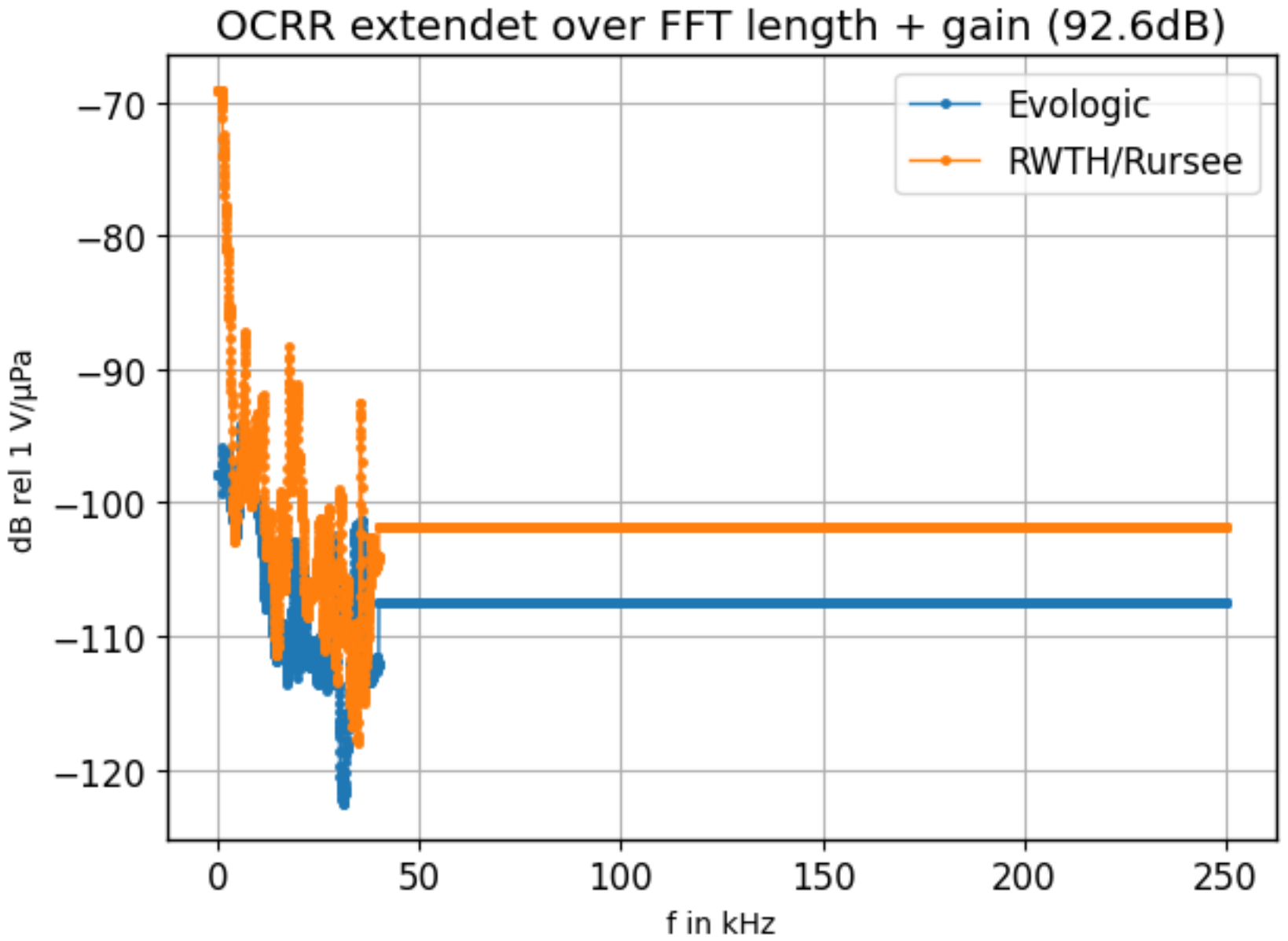
OCRR corrected for the FFT length and subtracting the gain od the signal



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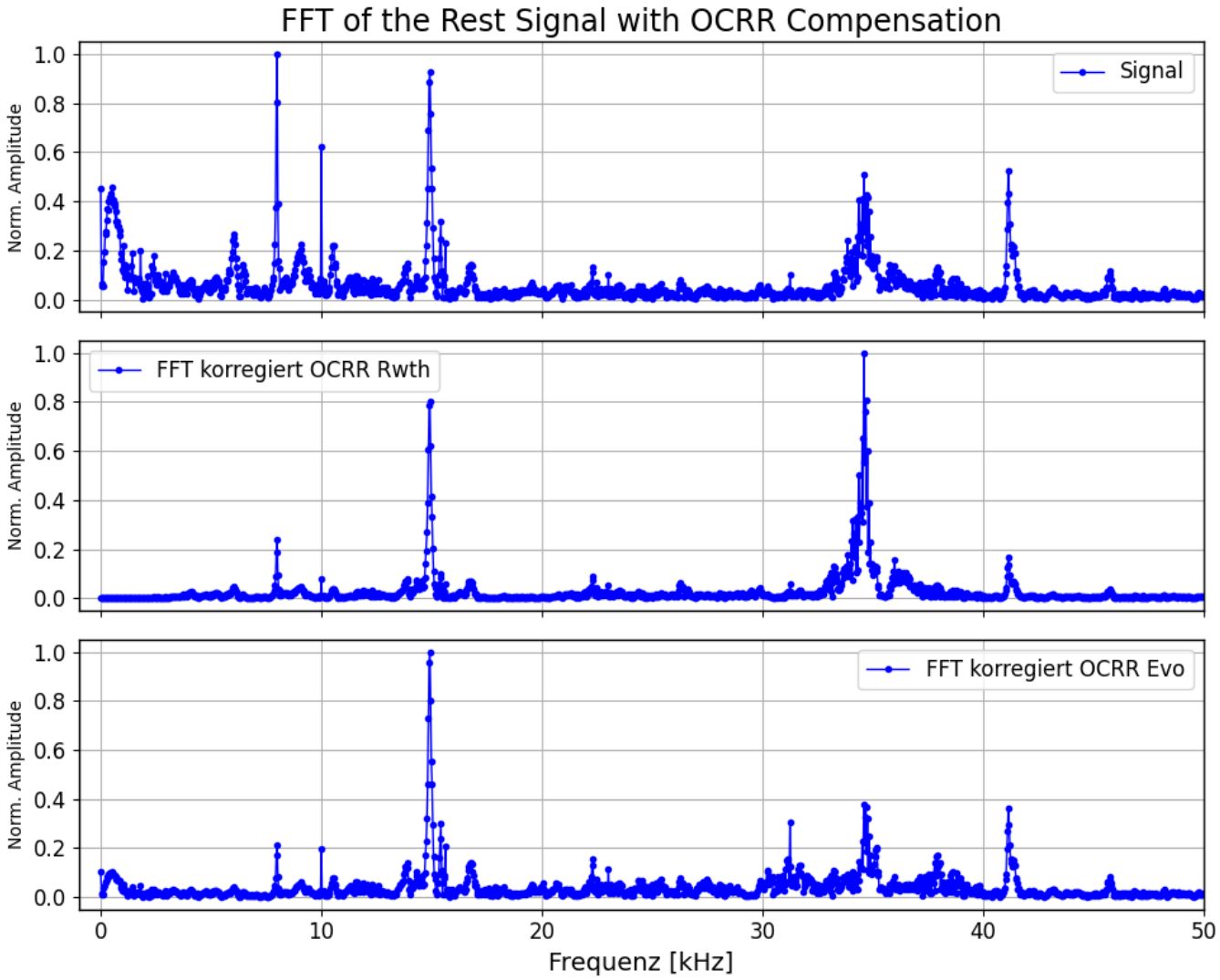
FFT comparisons after OCRR calculation

- Higher peaks in the ~35kHz with RWTH OCRR
- OCRR Evologics lower peak at ~35kHz
- Big difference between RWTH and Evologics



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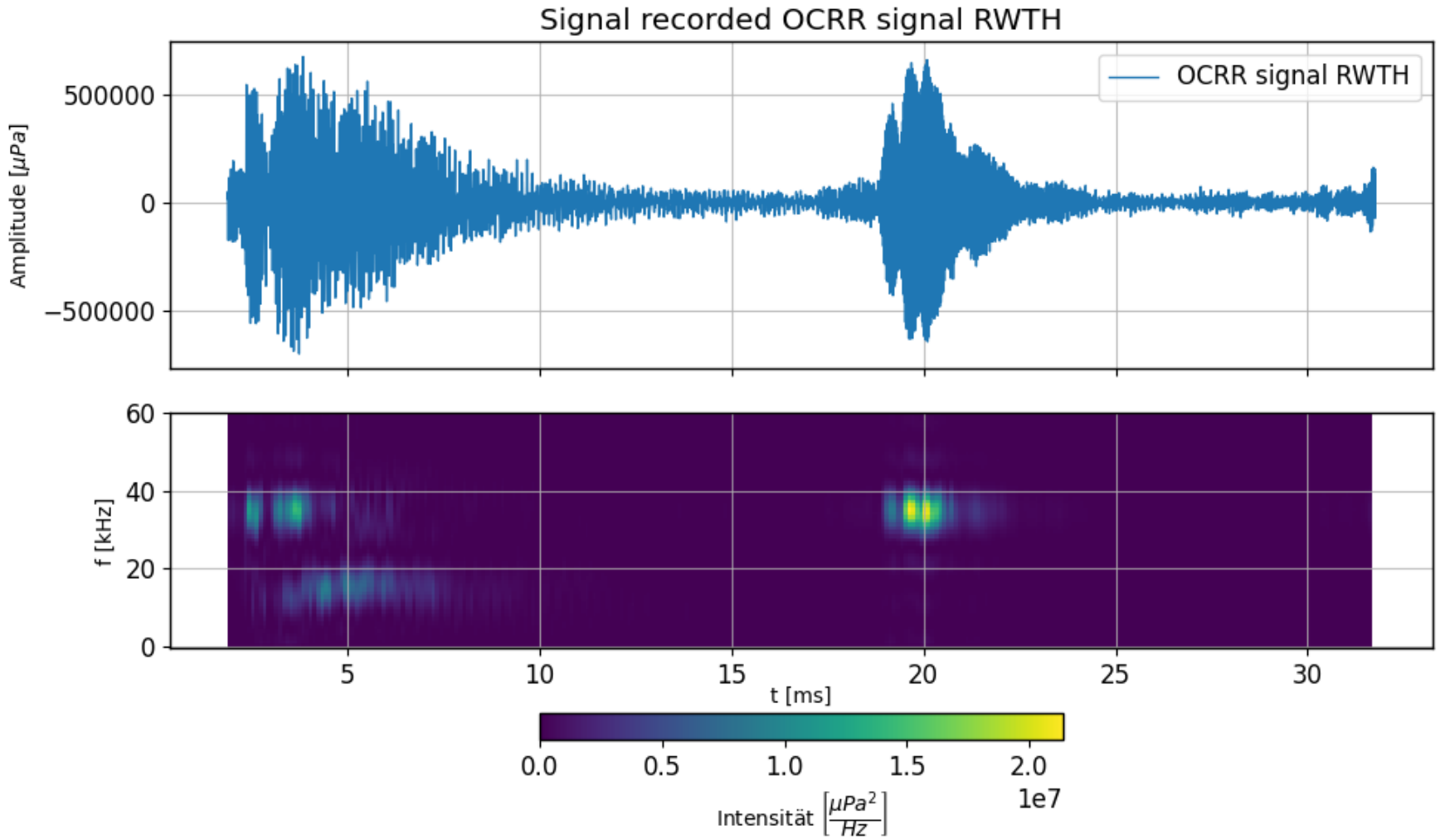
Resulting waveforms after RWTH-OCRR correction



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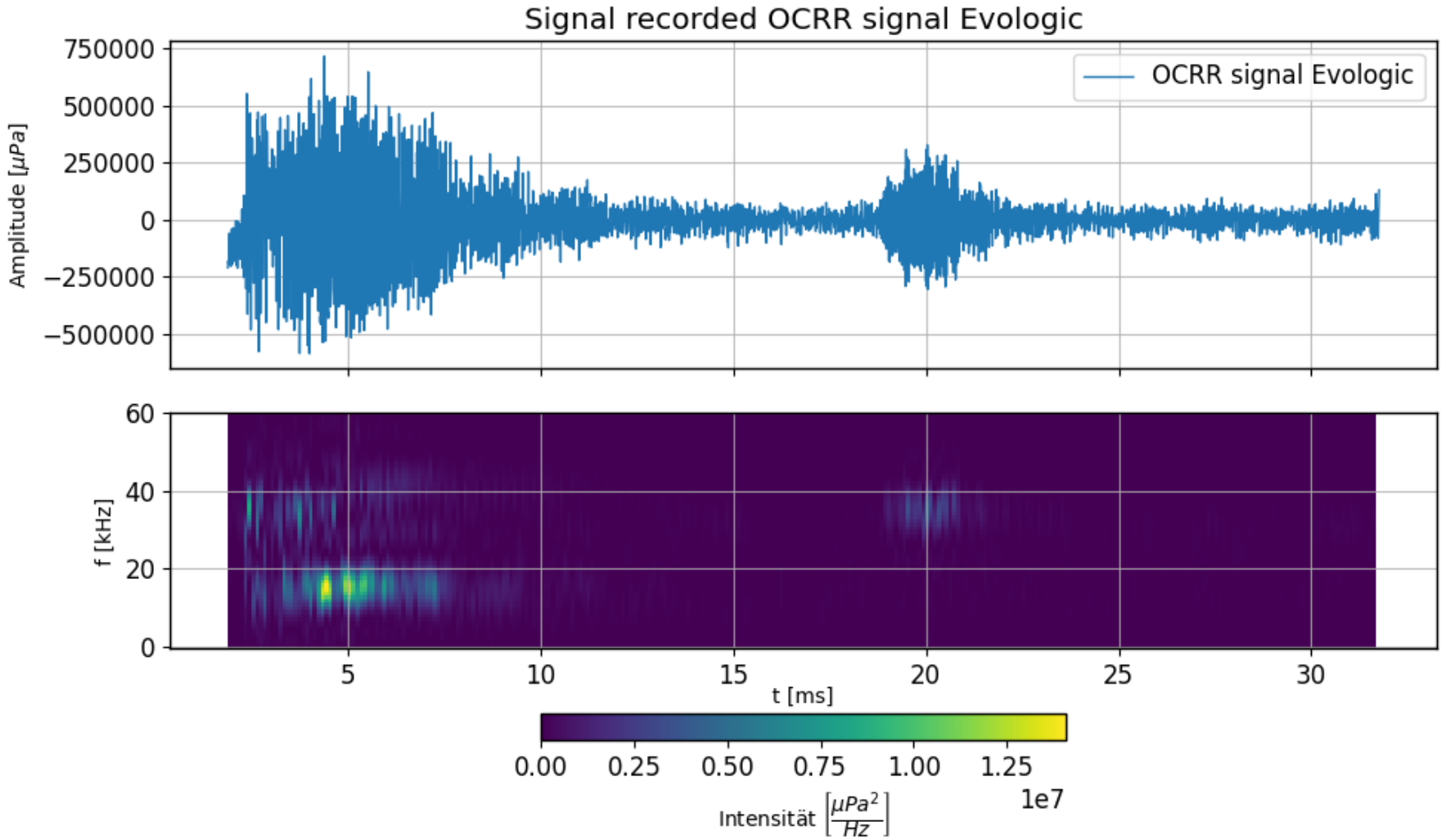
Resulting waveforms after Evologics-OCRR correction



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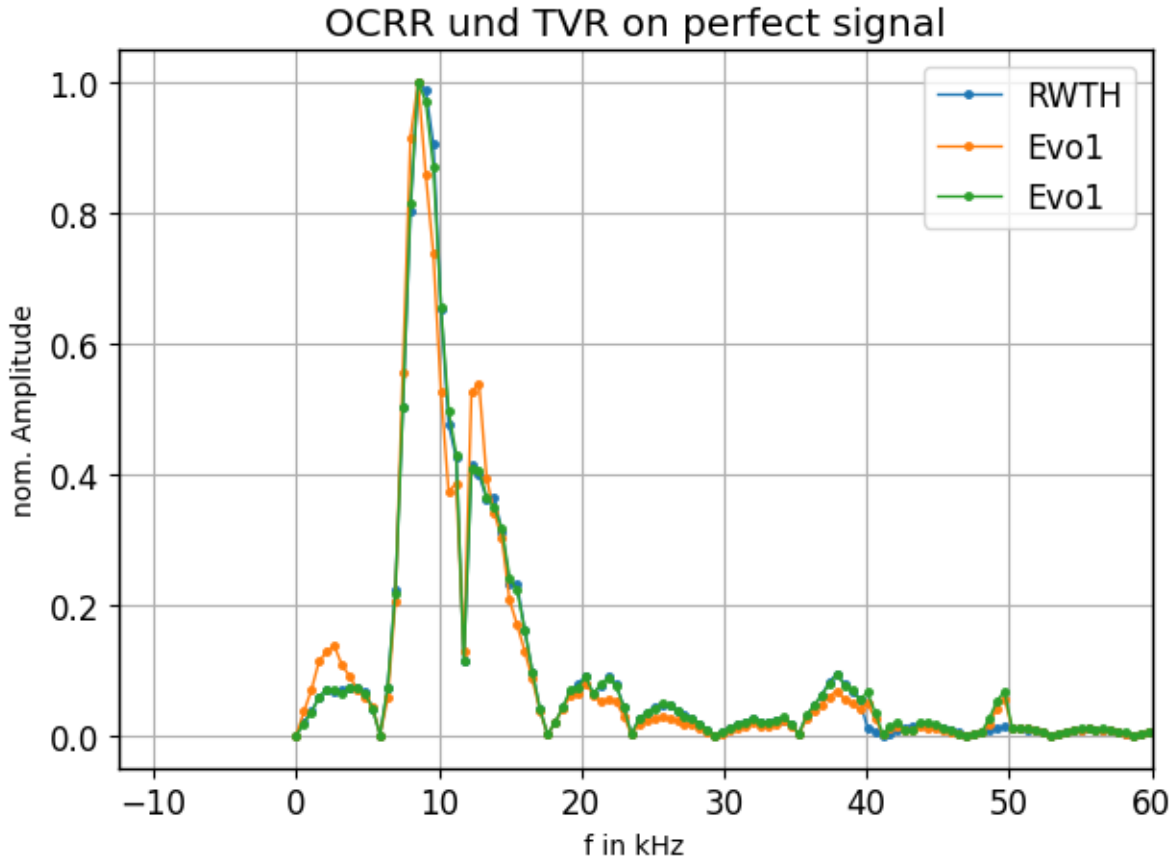
Perfect Signal with TVR and OCRR

- Calculating the response without neglecting the electronics
- Using the perfect signal and TVR and OCRR to get the response of the transducer

- $V_{receiving} = V_{signal} \cdot 10^{\frac{TVR\{frequency\}}{20}} \cdot 10^{\frac{OCRR\{frequency\}}{20}}$



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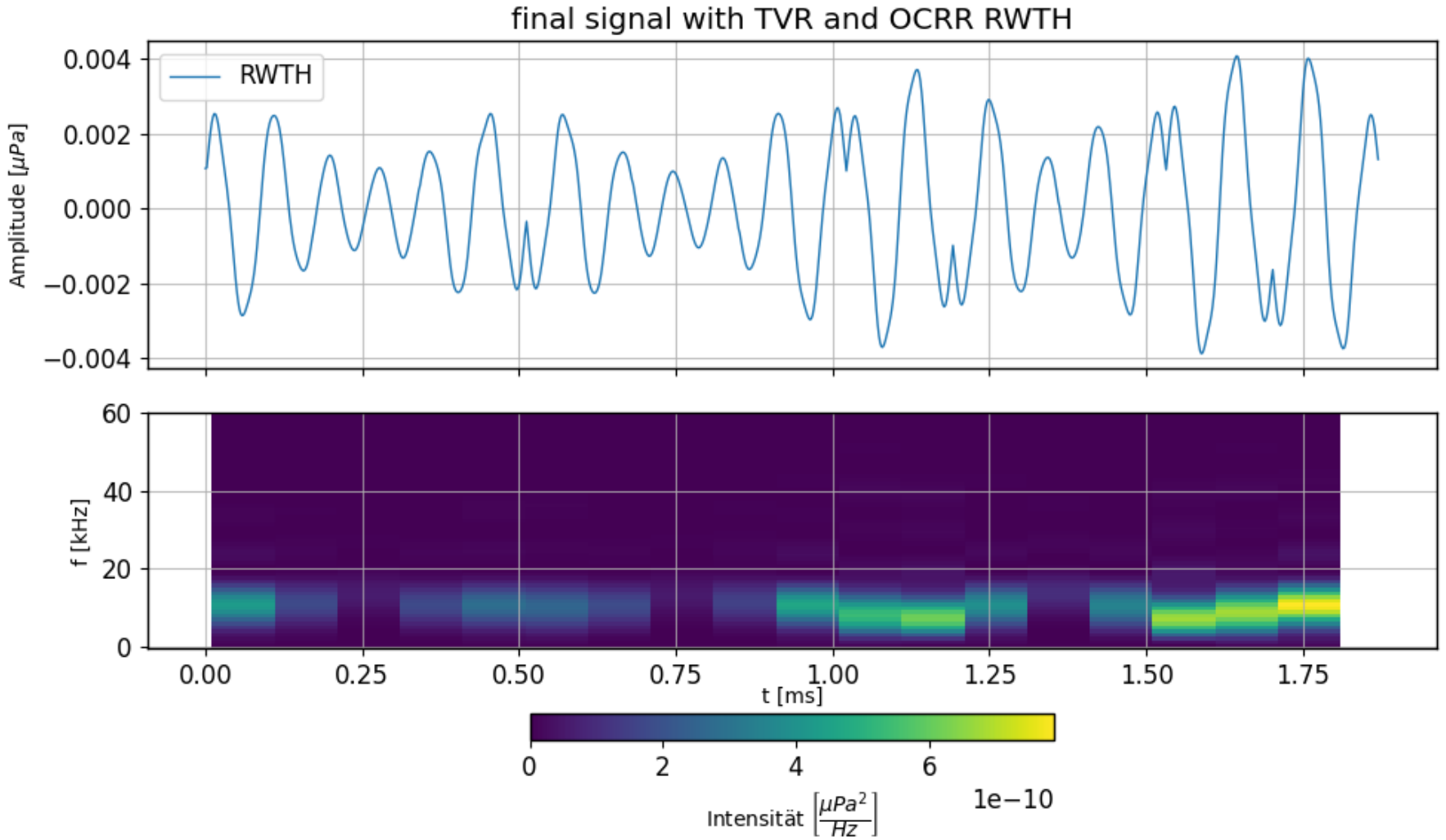
Final signal



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Conclusion / Outlook

- If the signal is transmitted as the perfect signal, no explanation for the higher frequency

- What does the actual signal look like?
- Does the Transducer already admit a higher frequency signal?
- Correlate the signal with the sending signal
- Getting an accurate and reliable distance measurement
- Figuring out the loss of the signal through the propagation of the melting channel

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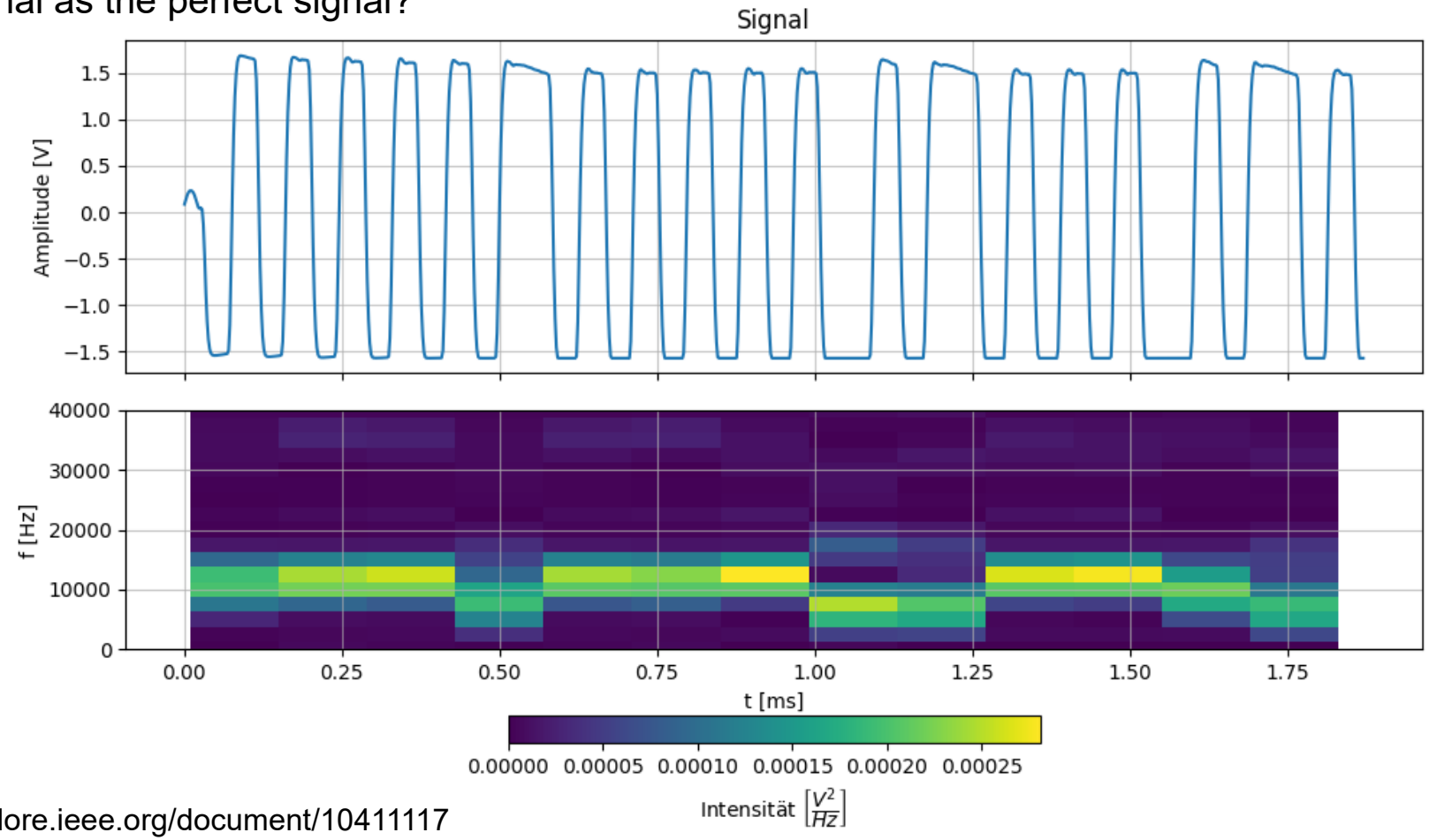
Signal that was send by the Piezoelectric Transducer

- Transducer approximates waveform through rectangular pulses [2]
  - Same signal as the perfect signal?



[2] https://ieeexplore.ieee.org/document/10411117

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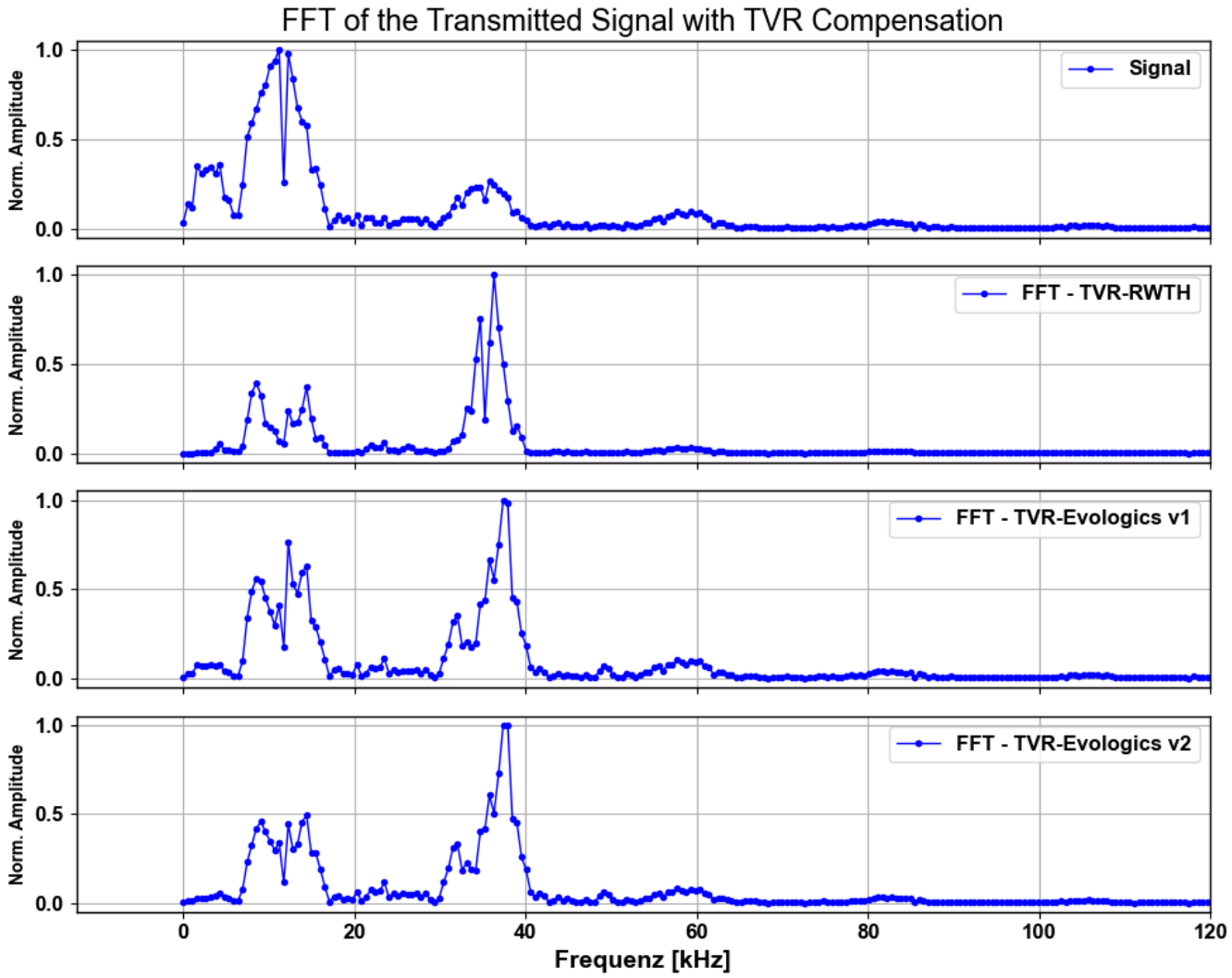
FFT comparisons after TVR calculation with actual Signal



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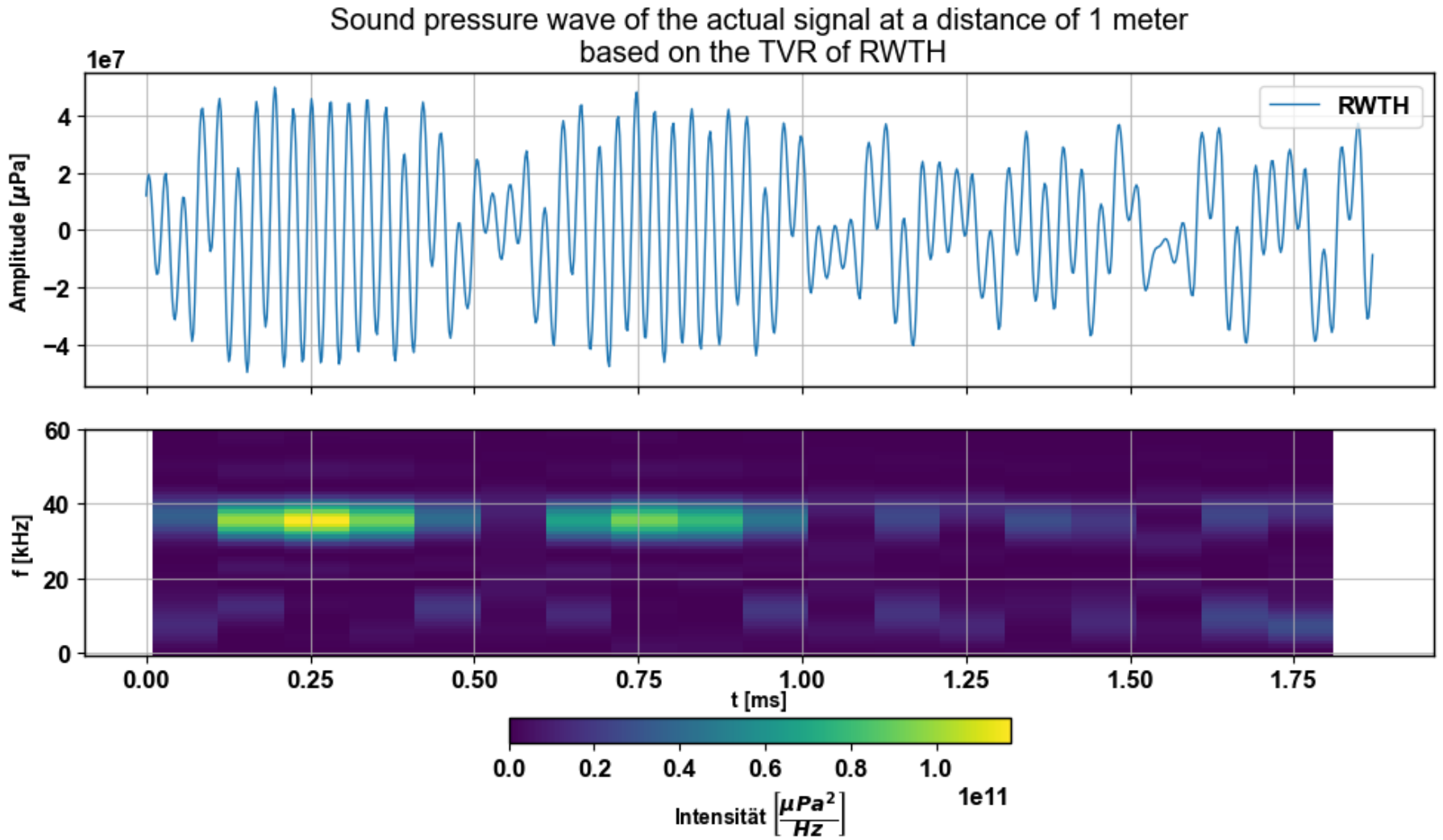
Resulting pressure wave at 1m distance with RWTH TVR



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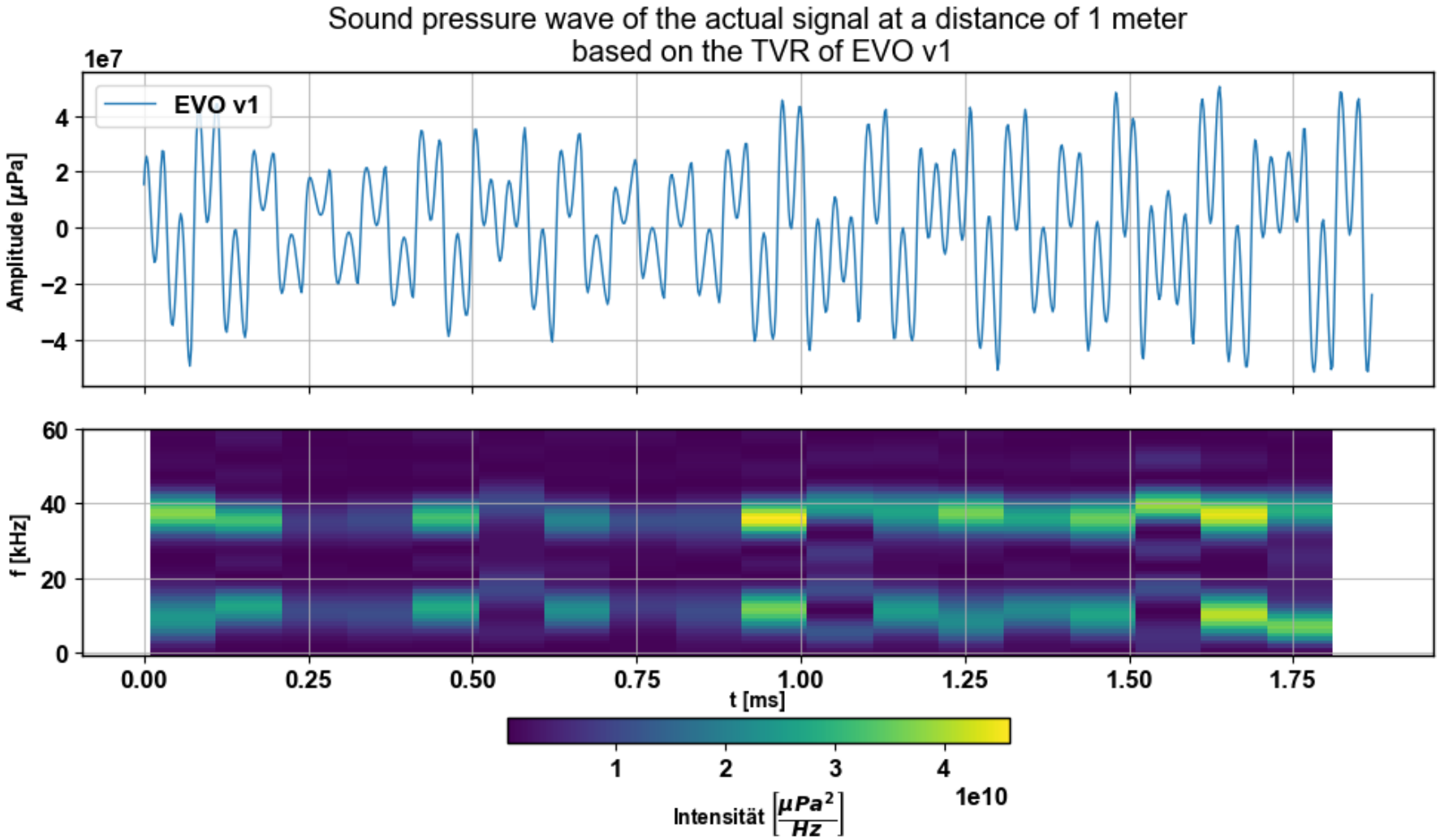
Resulting pressure wave at 1m distance with Evologics TVR v1



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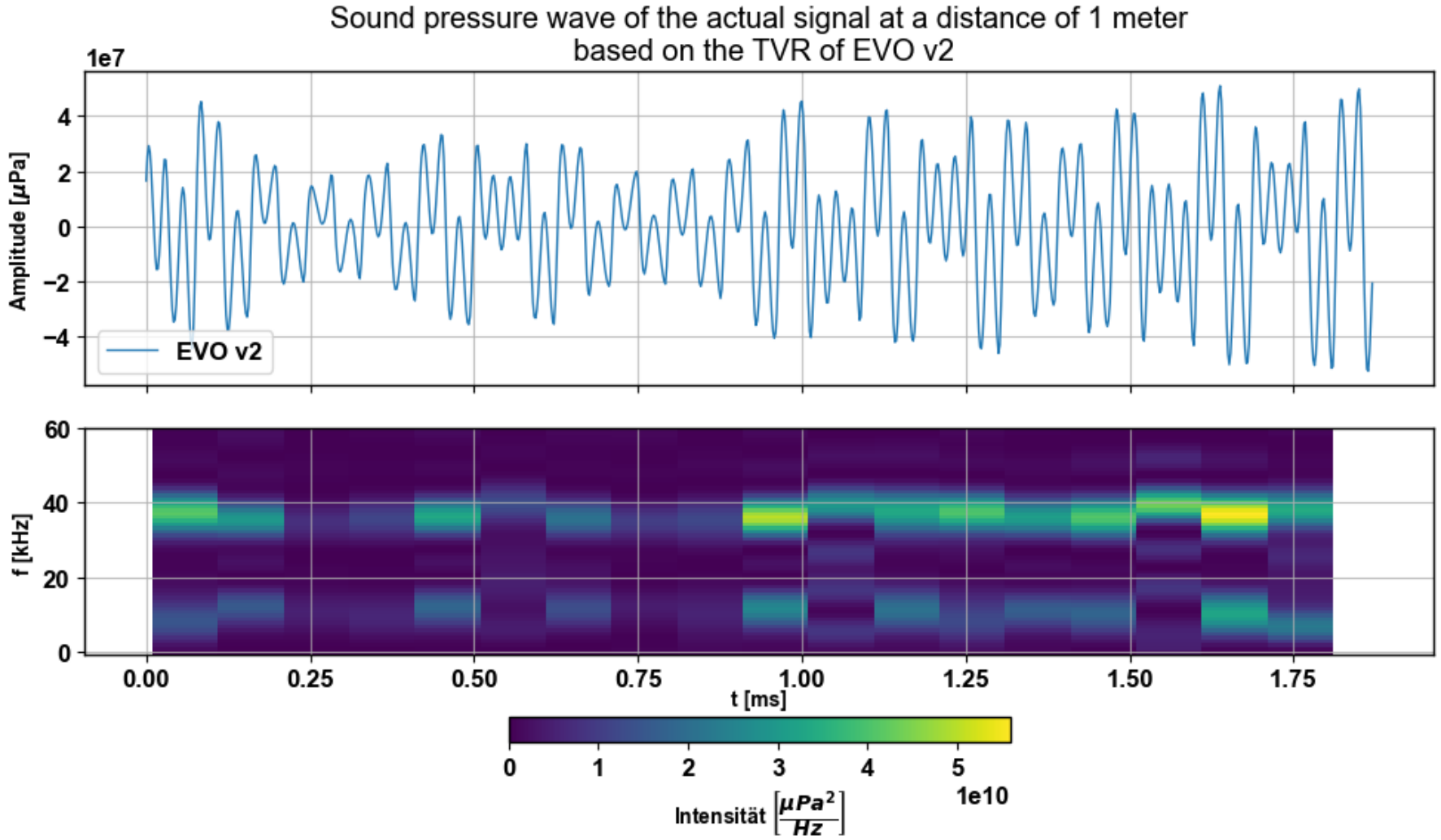
Resulting pressure wave at 1m distance with Evologics TVR v2



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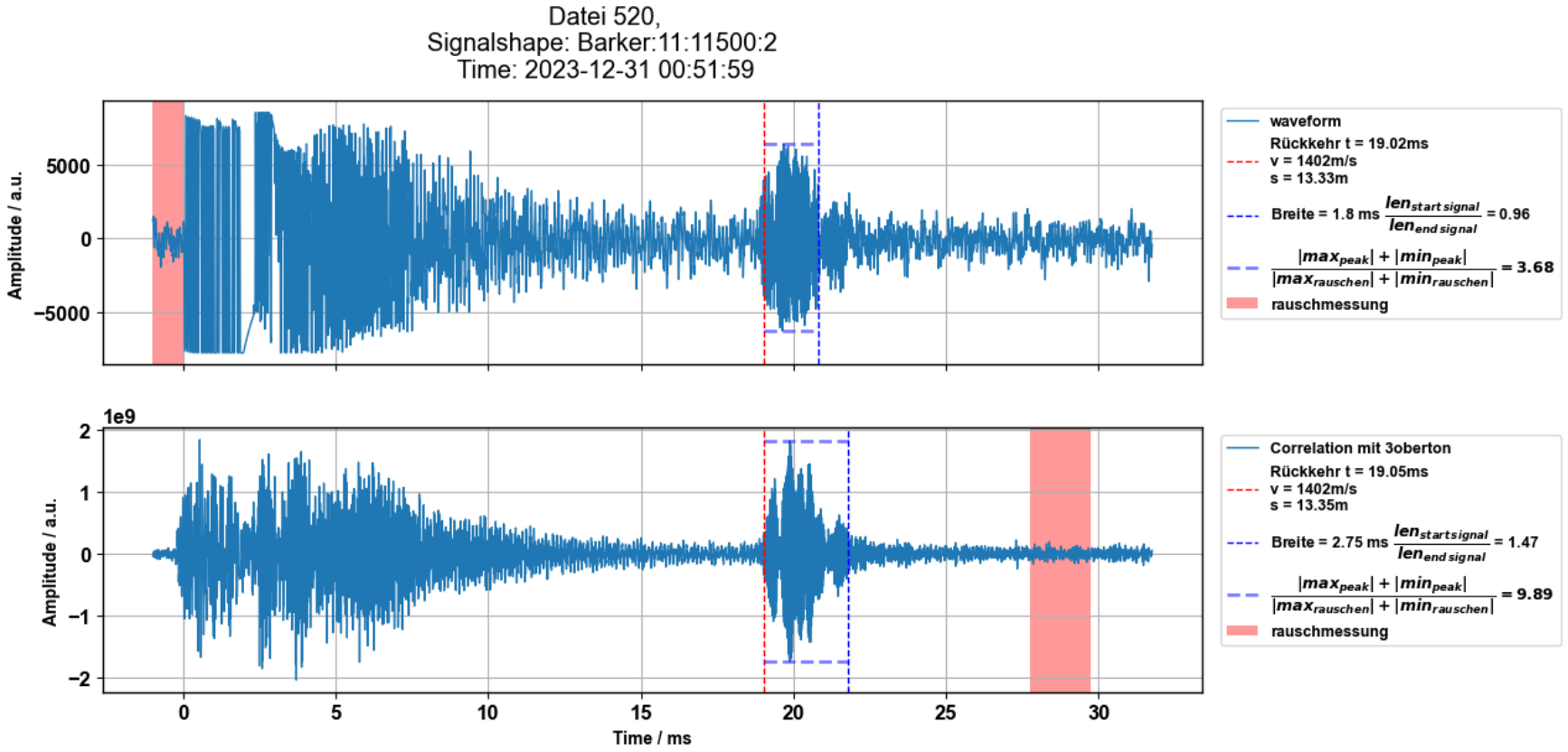
What I have tried

- Calculate the distance through a threshold condition
- Calculate the Cross-correlation with the 3rd harmonic of the perfect signal
  - To find out that it is the signal and not just some noise



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