

# Measurement methods for hearing aids

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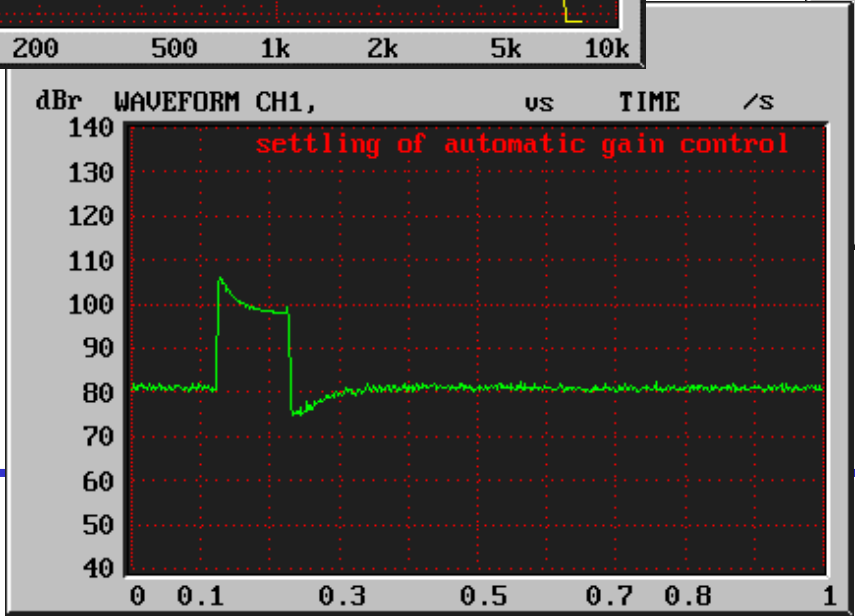
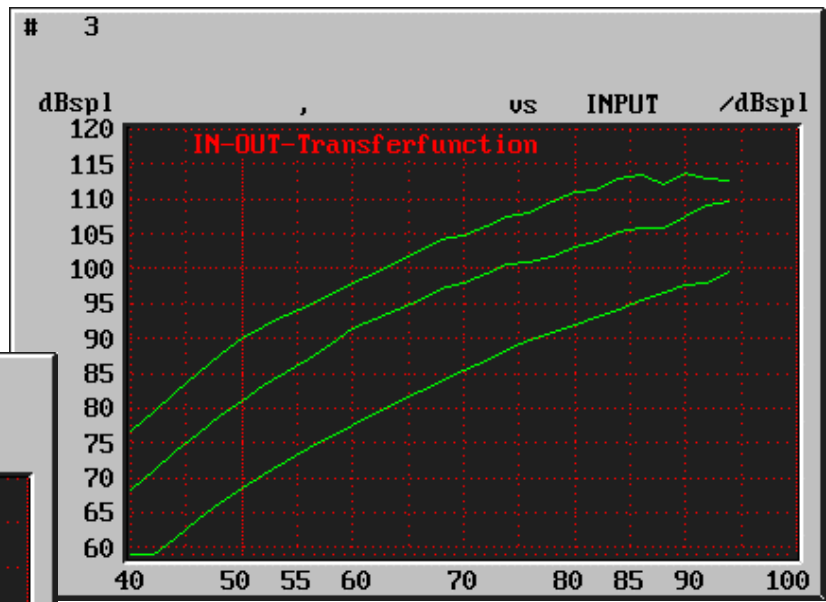
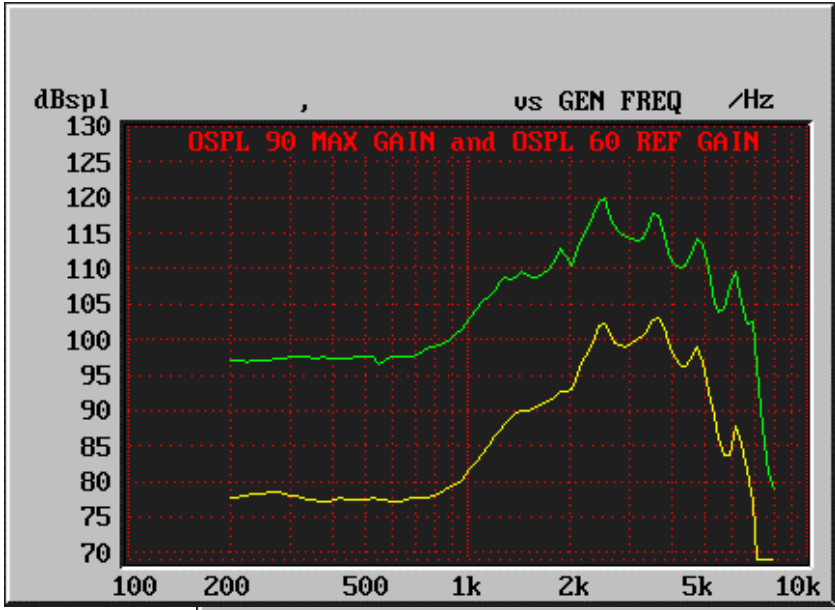
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# Current Status

- DIN IEC 60118
- Testbox measurements
- Sinusoid or broadband noise
- Frequency response
- Input-output functions
- Attack and release times
- Distortions, noise

# Conventional Methods

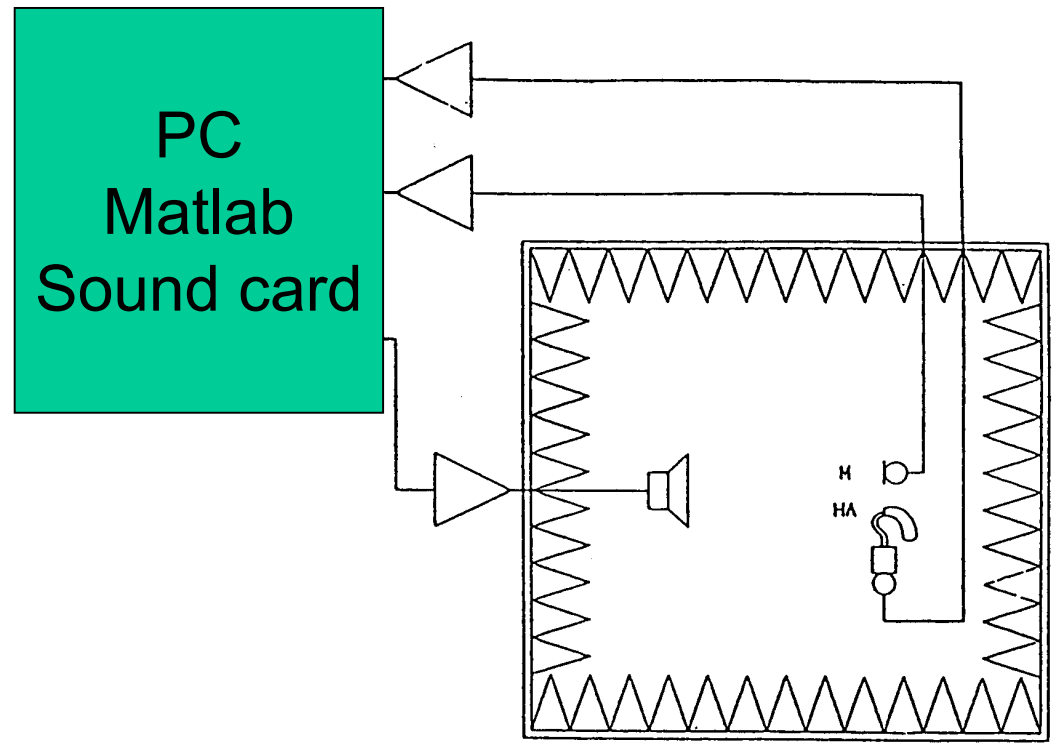


# But:

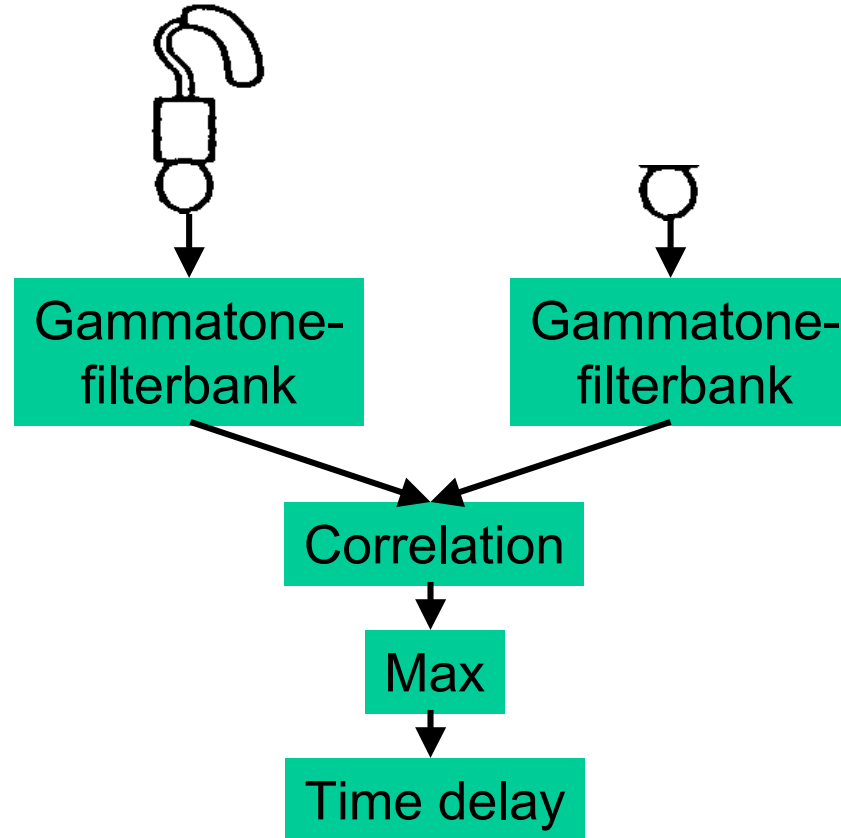
- Artificial stimuli
- Stationary characteristics
- Perzeption?
- Goal: Development of a new measurement method to characterize nonlinear hearing aids
- First steps:
  - Time delay
  - Modulation transfer function (MTF)



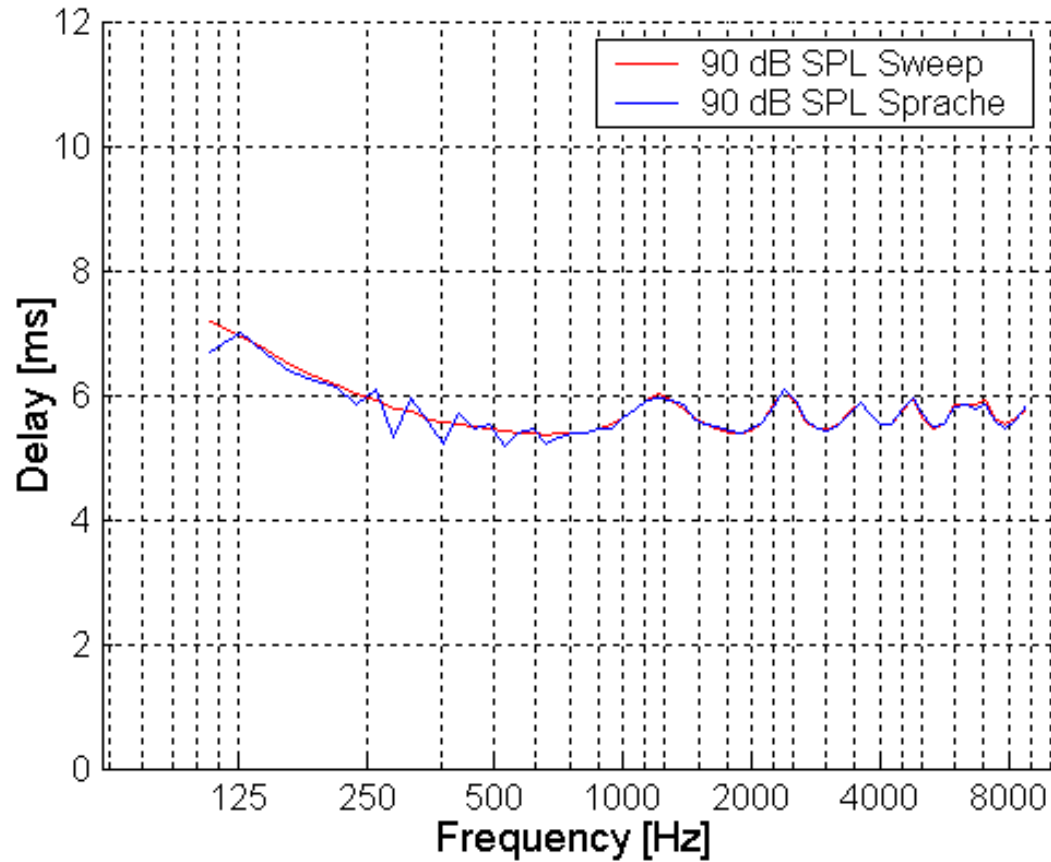
# Sound Recording



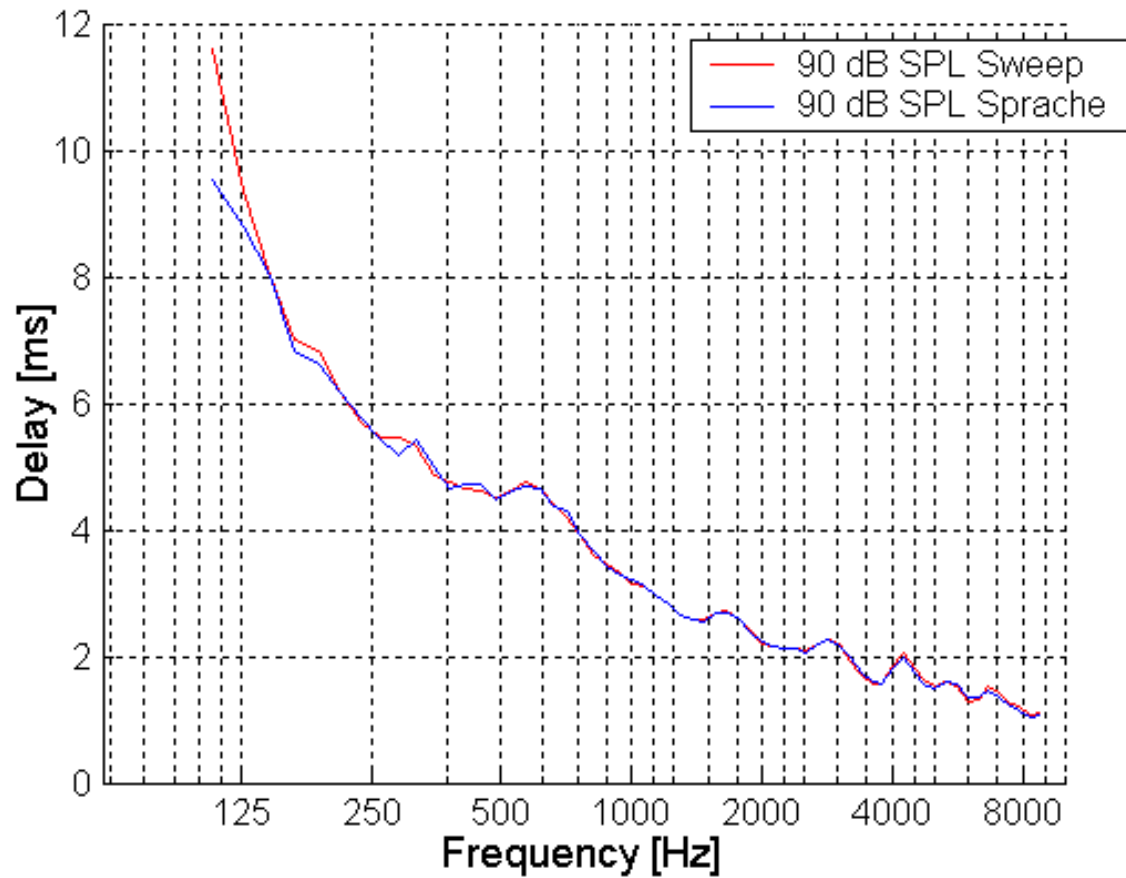
# Time delay in digital instruments



# FFT-Instrument

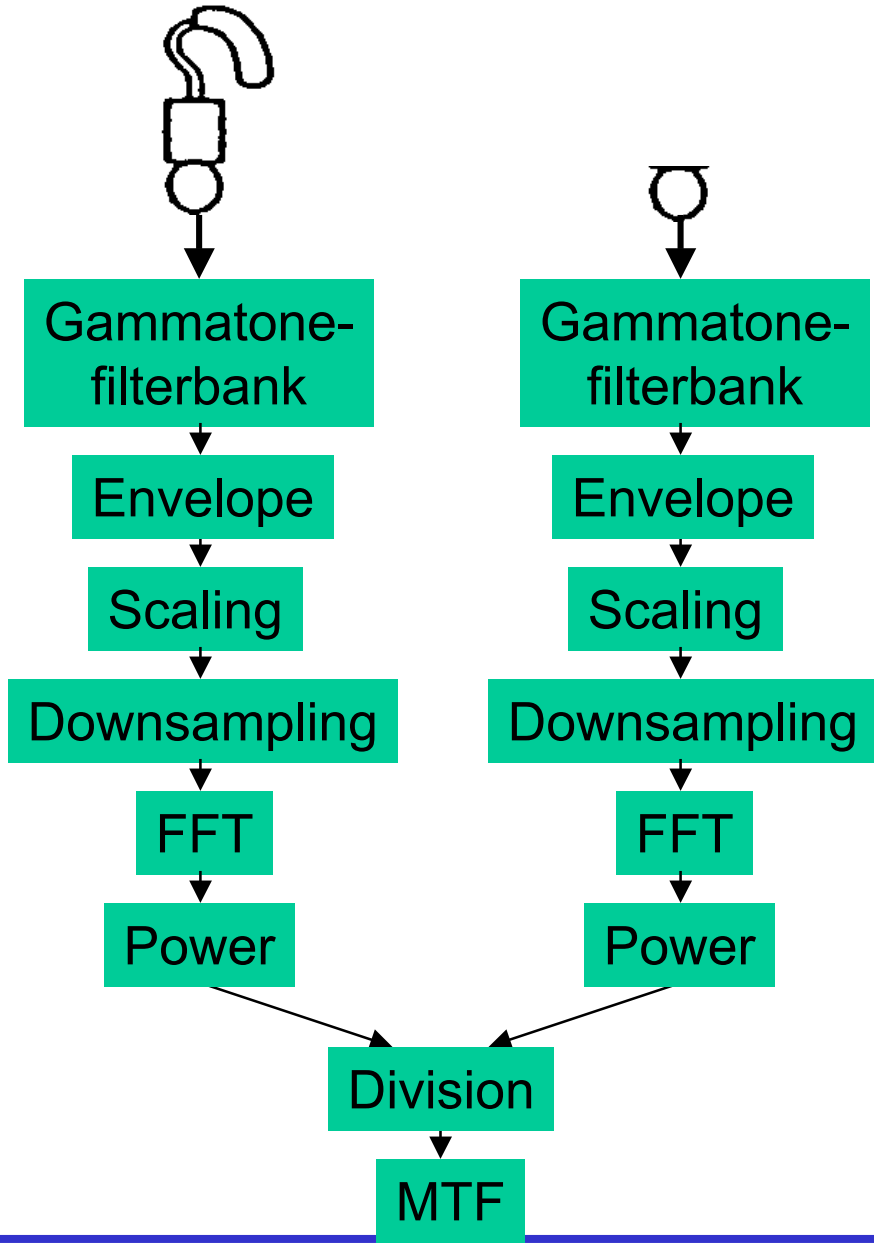


# Filterbank-Instrument



# Modulation Frequency Analysis

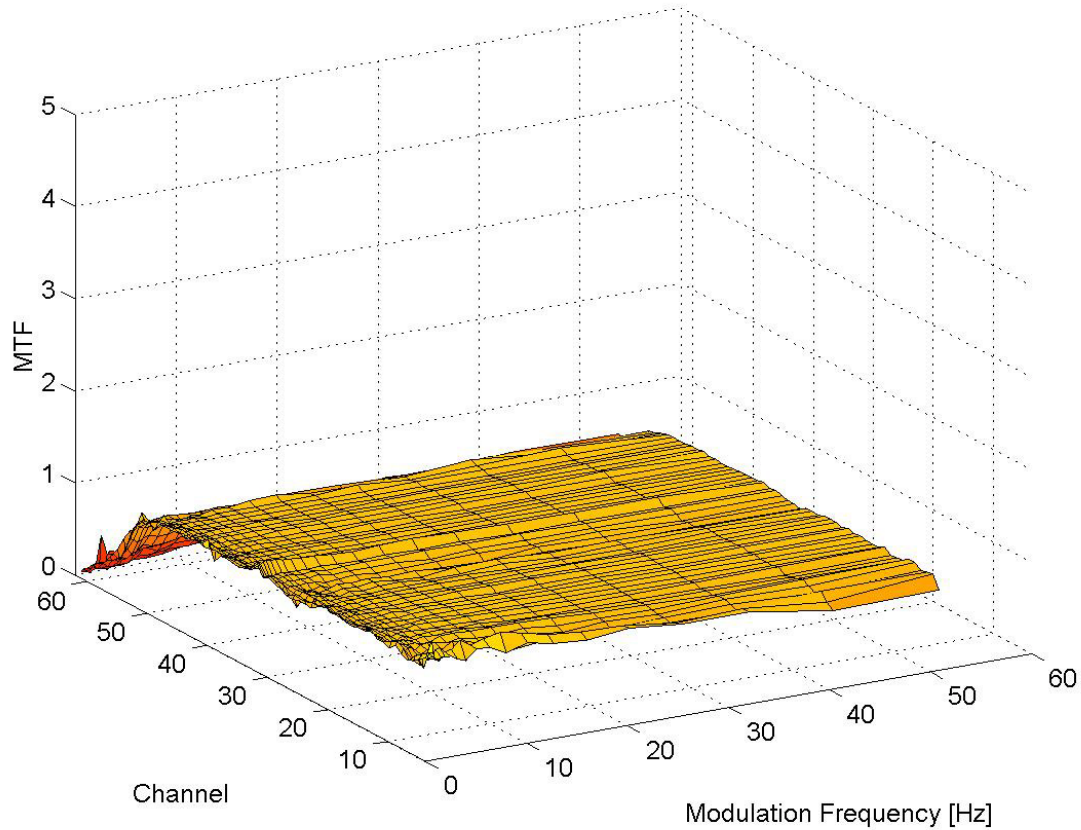
- Classification of listening situations
- Noise reduction
- Modelling of psychoacoustical experiments
- Speech intelligibility prediction (STI)



# Calculation of MTF

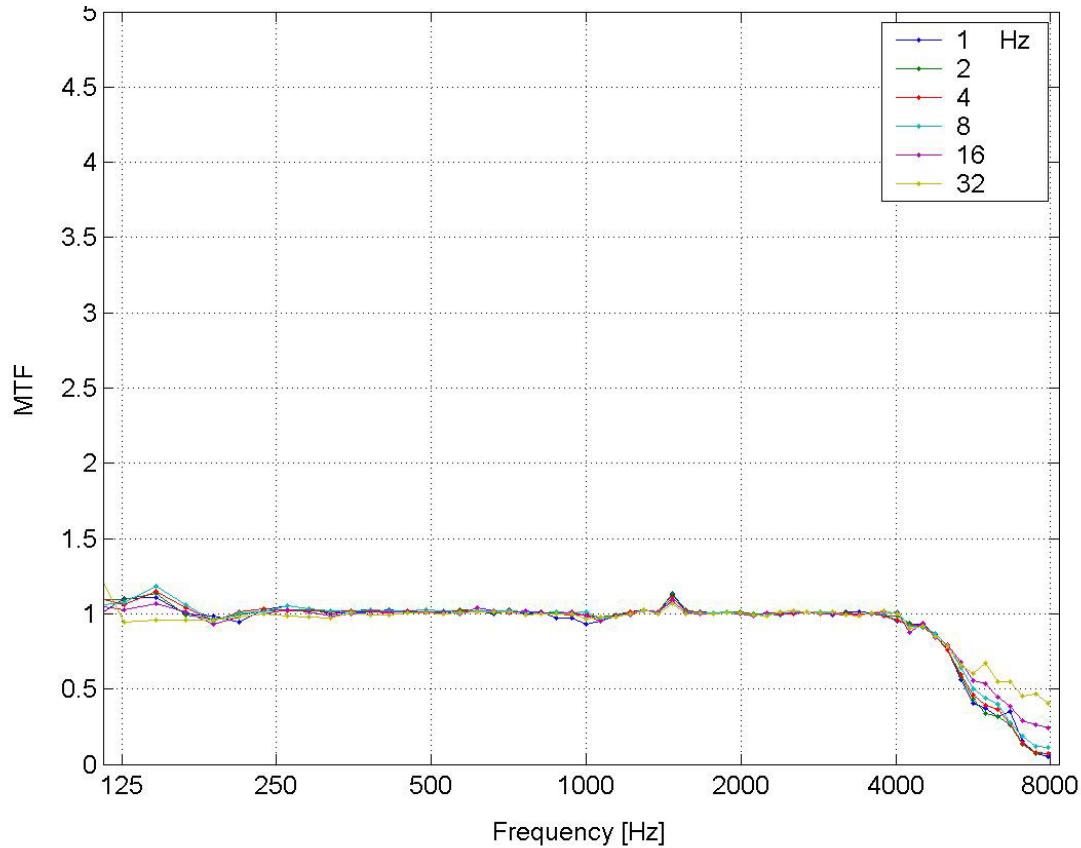
- Speech as measurement signal
- Duration: 20 s
- Frequency range: 125 Hz – 8 kHz
- Gammatone-Filterbank with 2 filters per ERB, bandwidth: ERB/2
- Modulation frequency: 1/3-octave bandwidth

# Instrument A without Compression

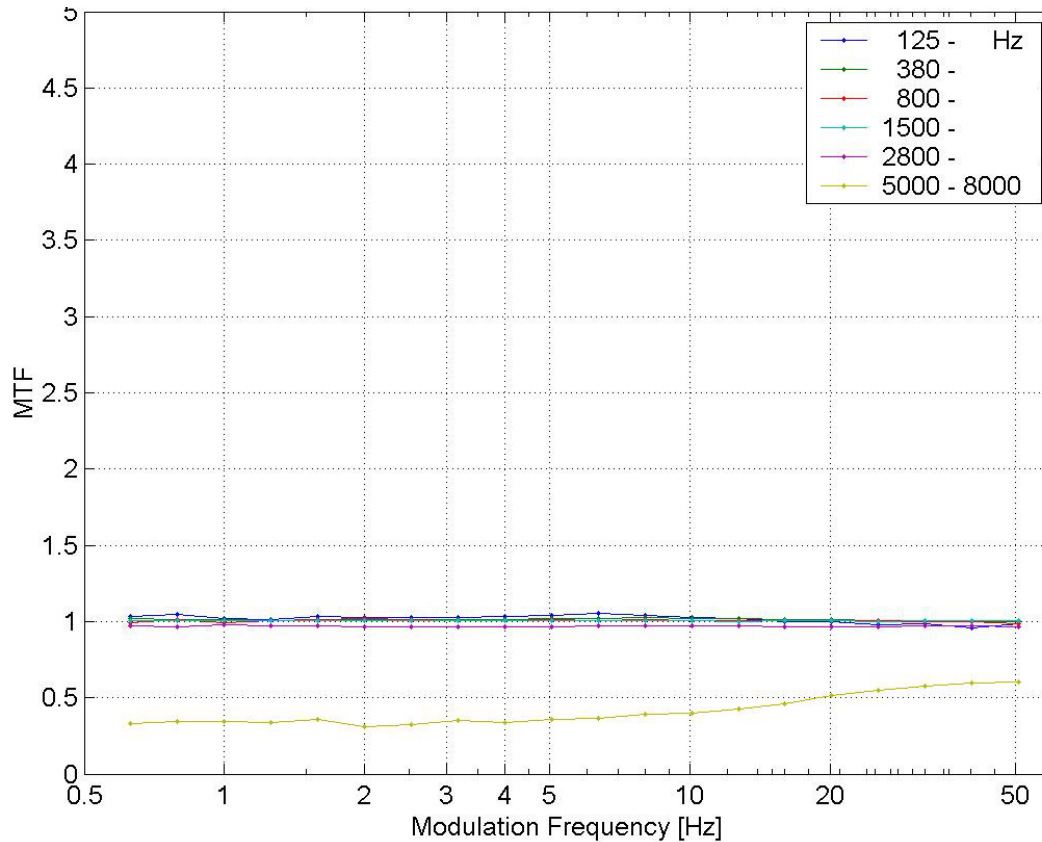




# Instrument A without Compression

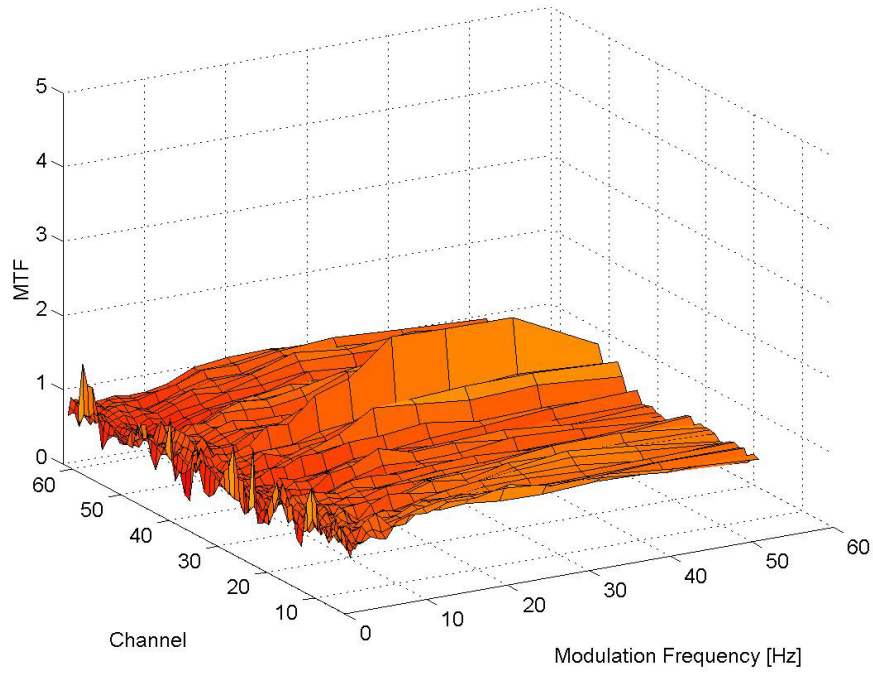


# Instrument A without Compression

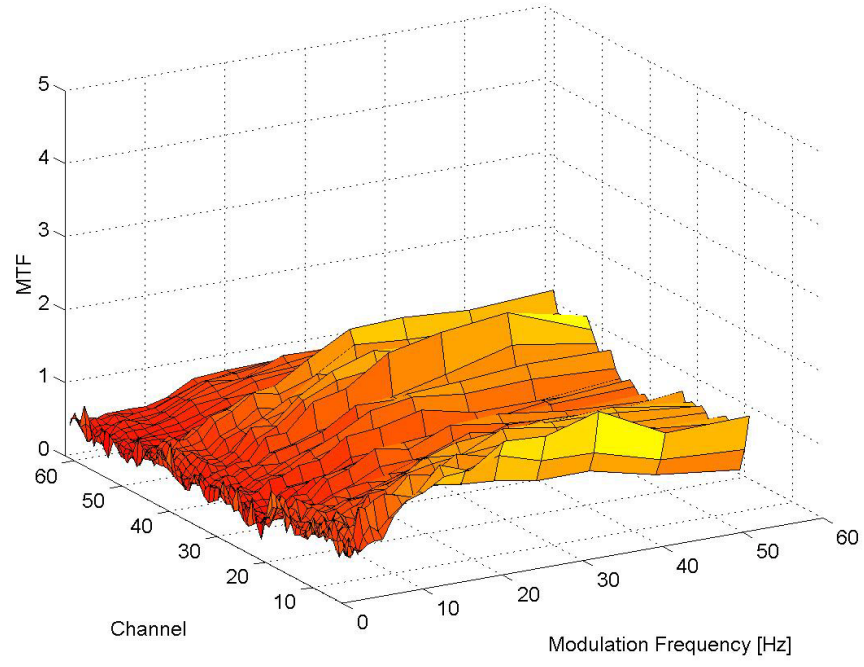


# Algorithm

Algorithmus mit langen Zeitkonstanten

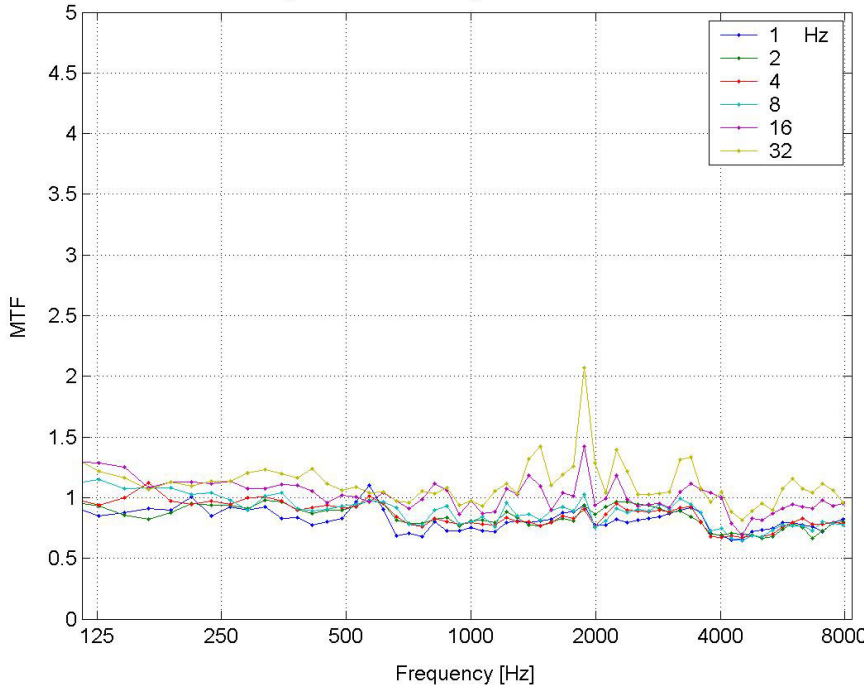


Algorithmus mit kurzen Zeitkonstanten

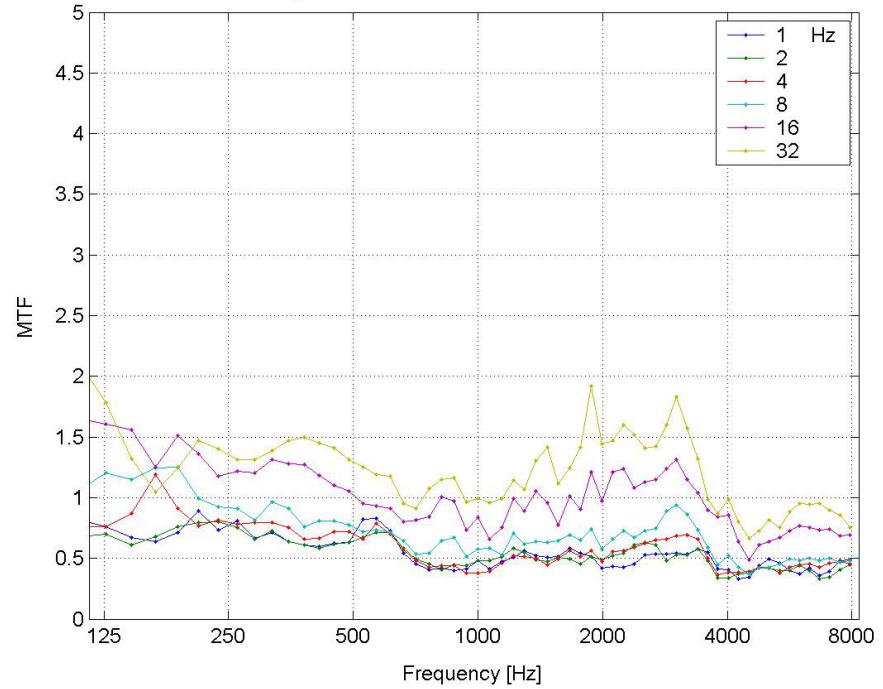


# Algorithm

Algorithmus mit langen Zeitkonstanten

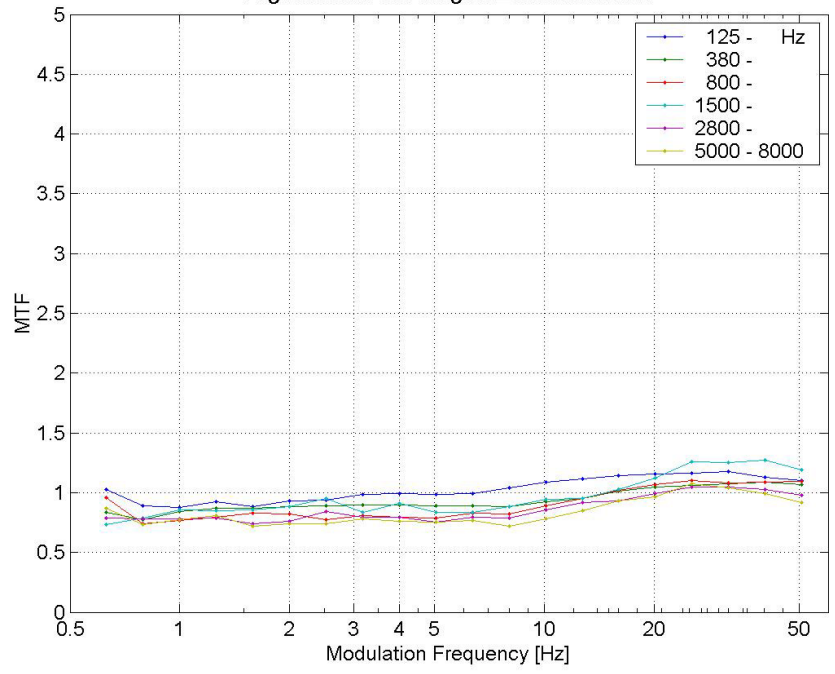


Algorithmus mit kurzen Zeitkonstanten

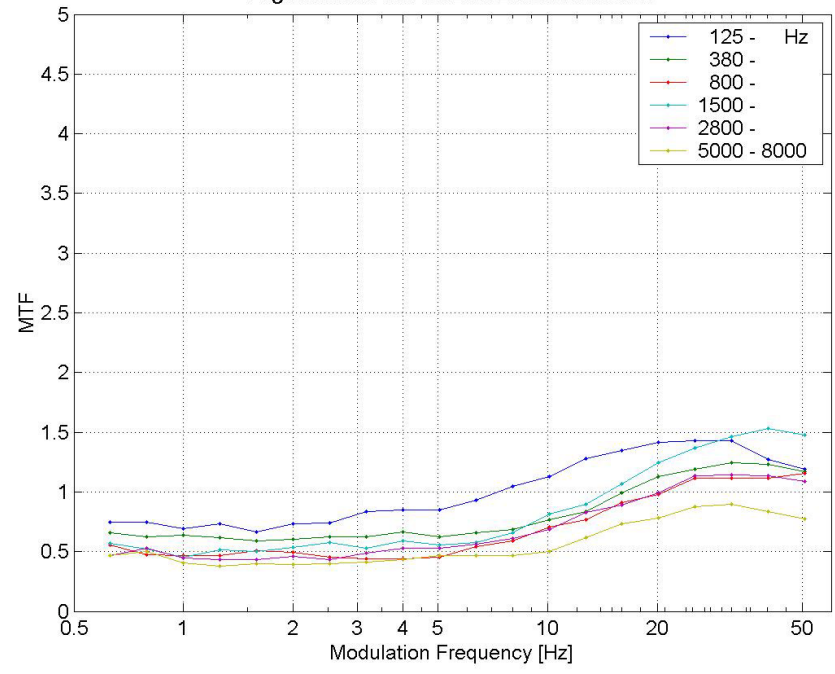


# Algorithm

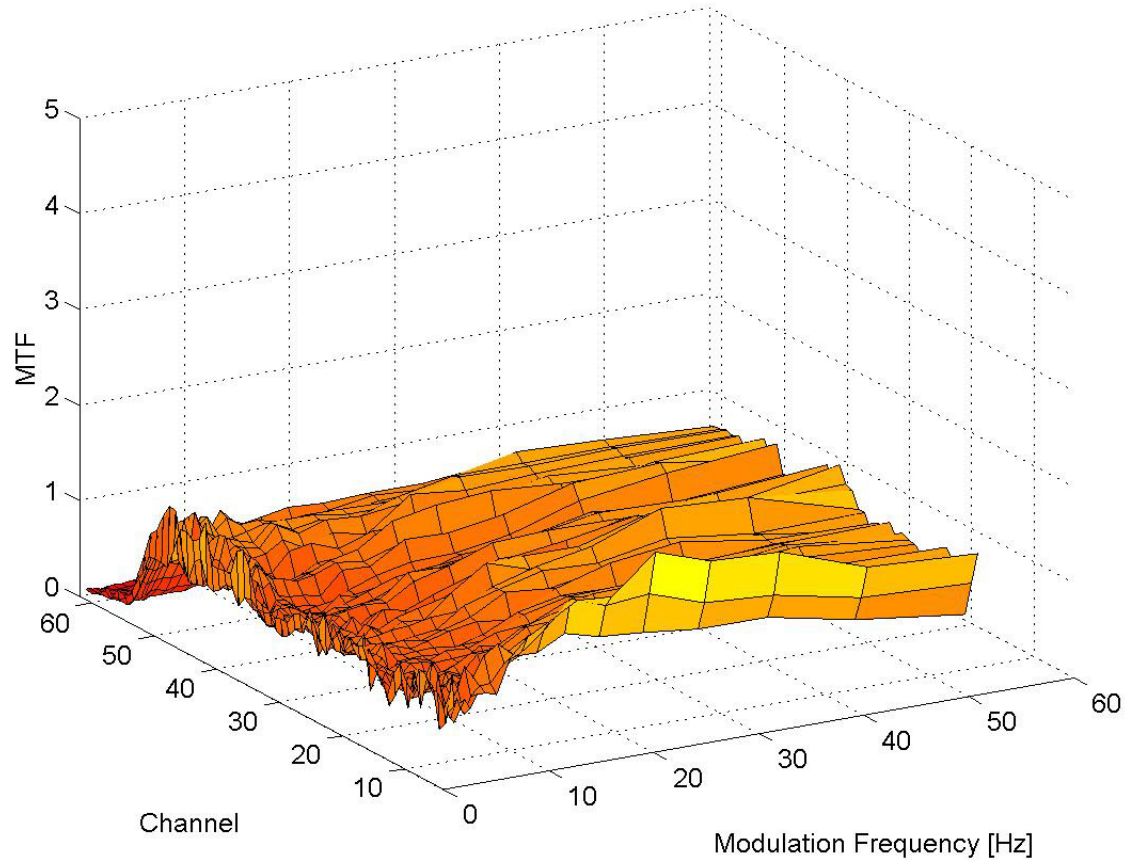
Algorithmus mit langen Zeitkonstanten



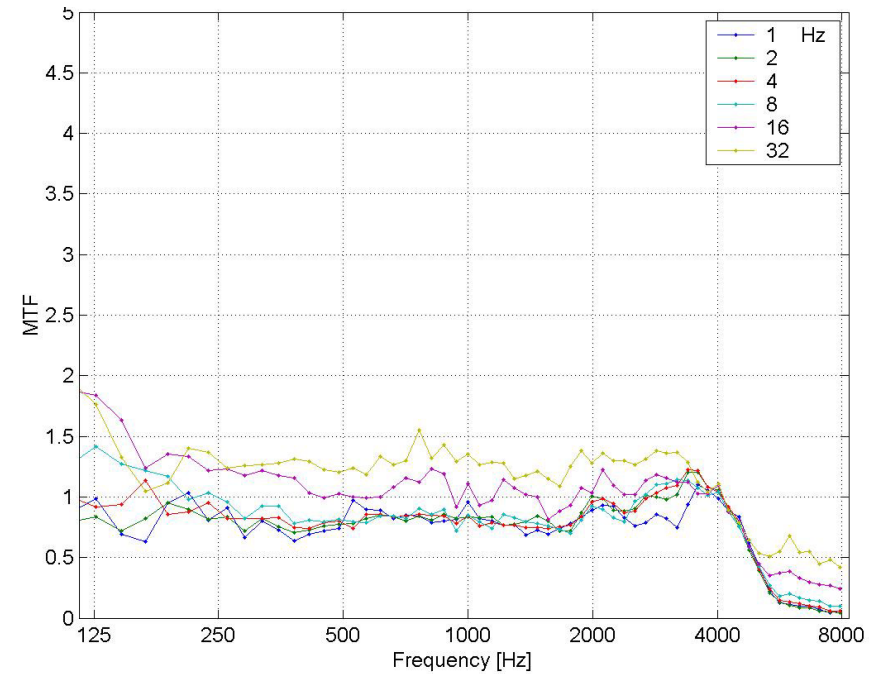
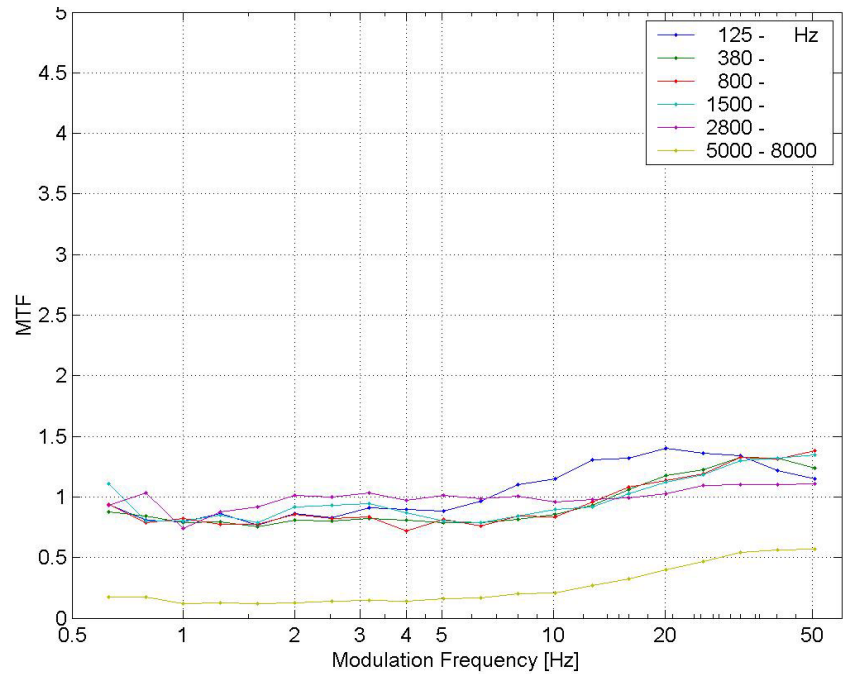
Algorithmus mit kurzen Zeitkonstanten



# Instrument A with Compression



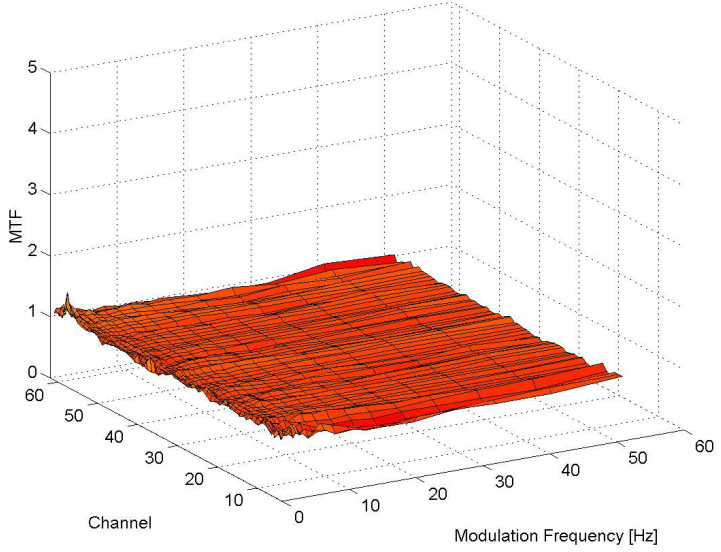
# Instrument A with Compression



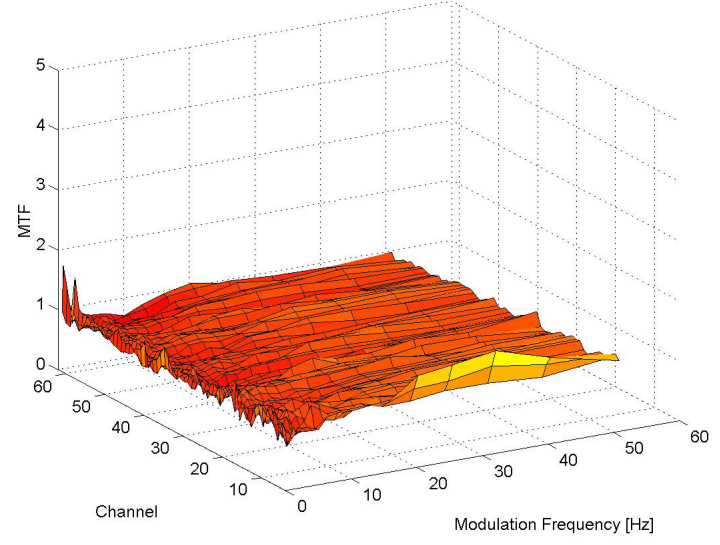


# Instrument B

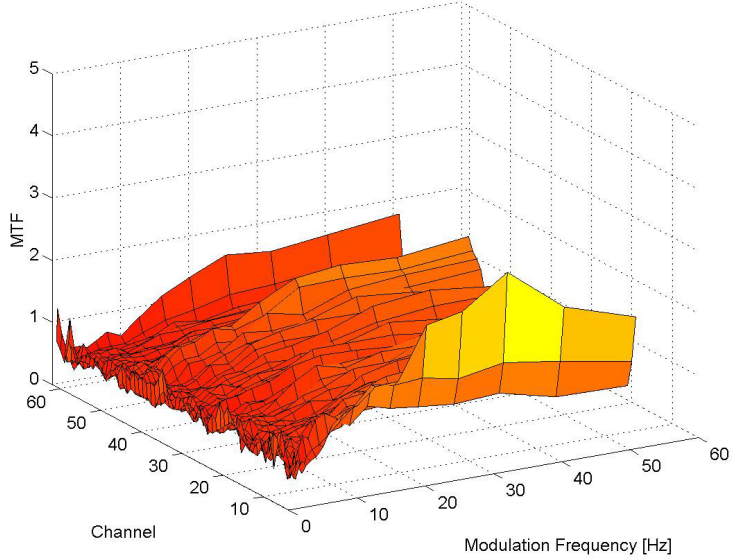
HG B - ohne Dynamikkompression



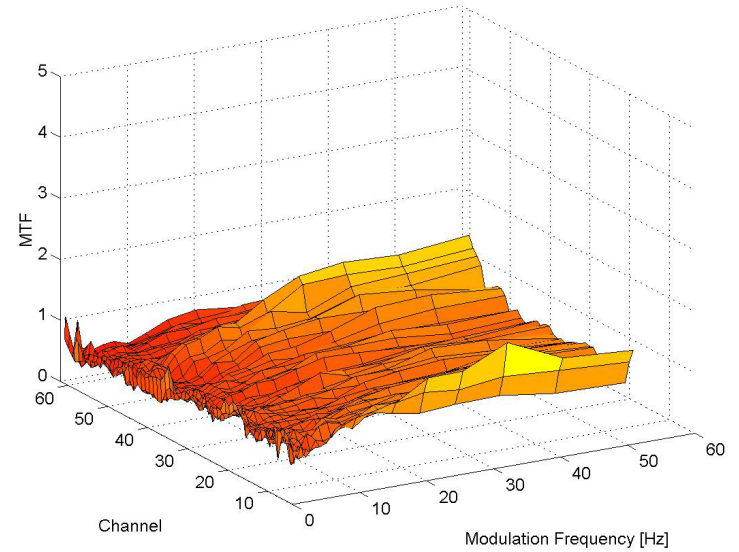
HG B - mit DK lange Zeitkonst.



HG B - mit DK kurze Zeitkonst.



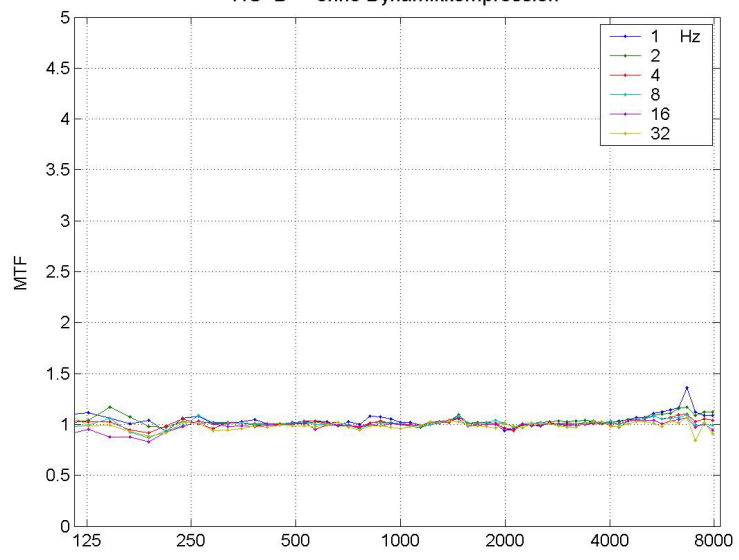
HG B - mit DK variables CR



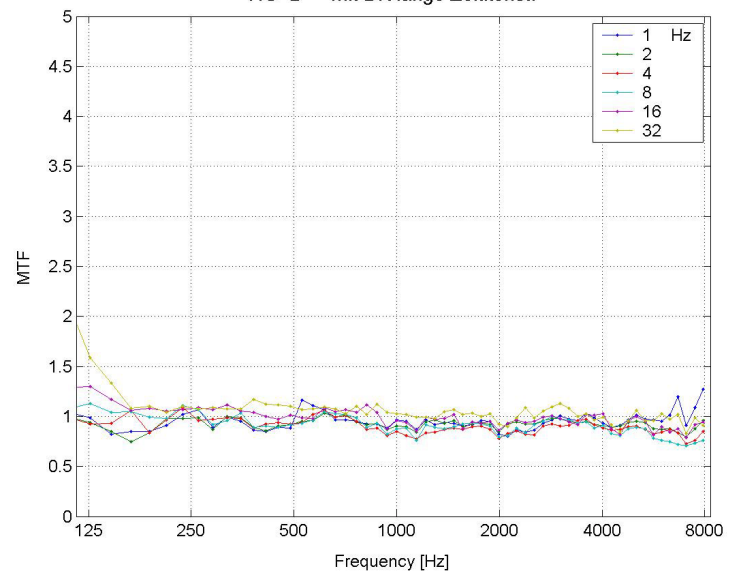


# Instrument B

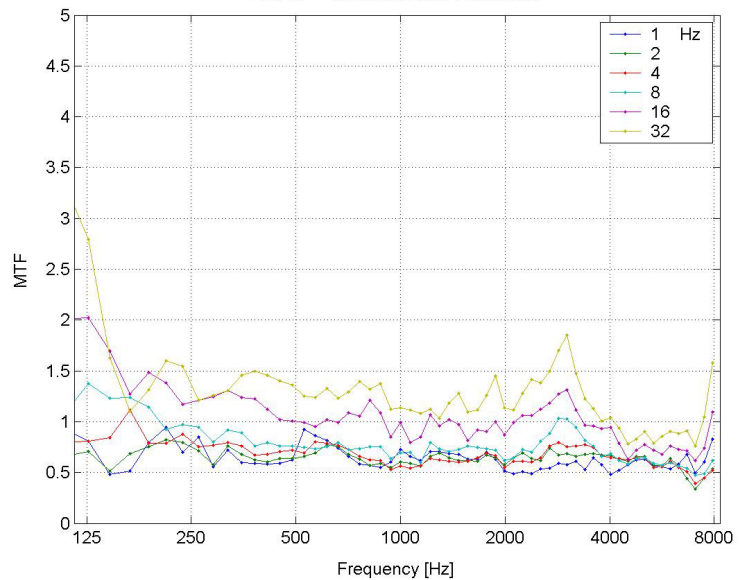
HG B - ohne Dynamikkompression



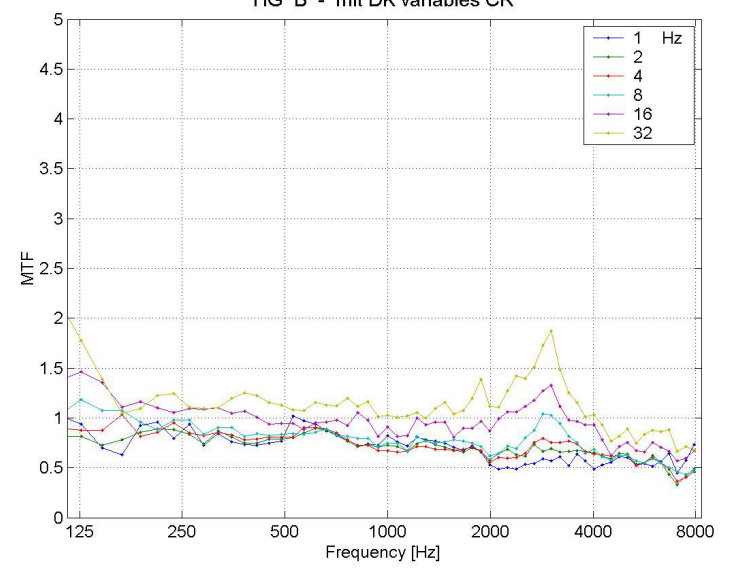
HG B - mit DK lange Zeitkonst.



HG B - mit DK kurze Zeitkonst.

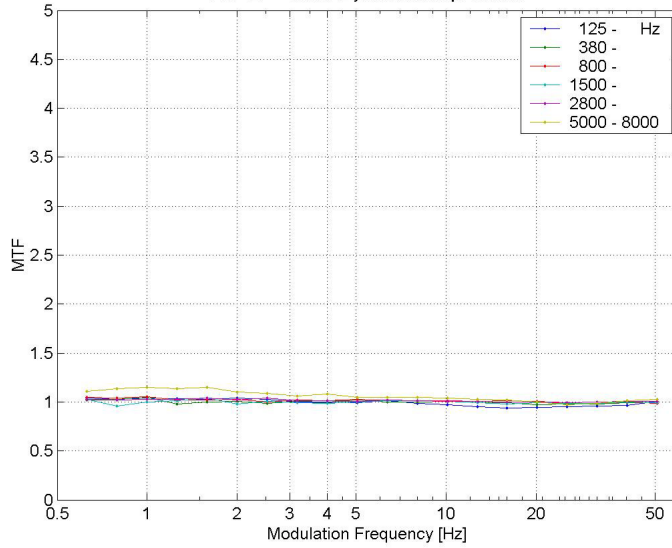


HG B - mit DK variables CR

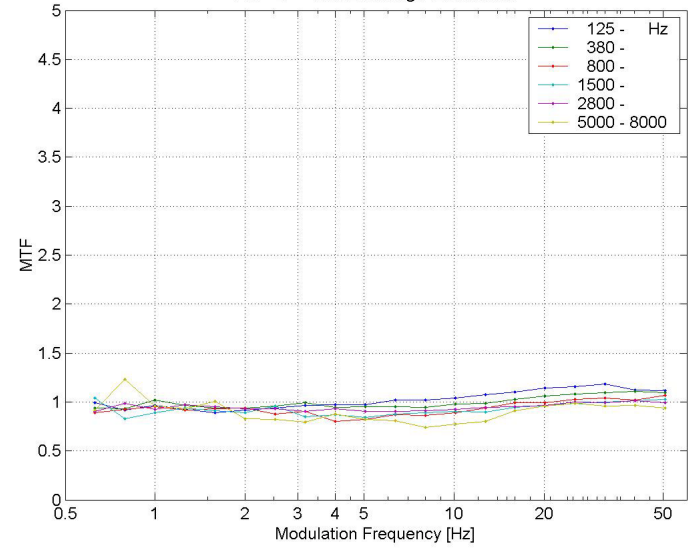


# Instrument B

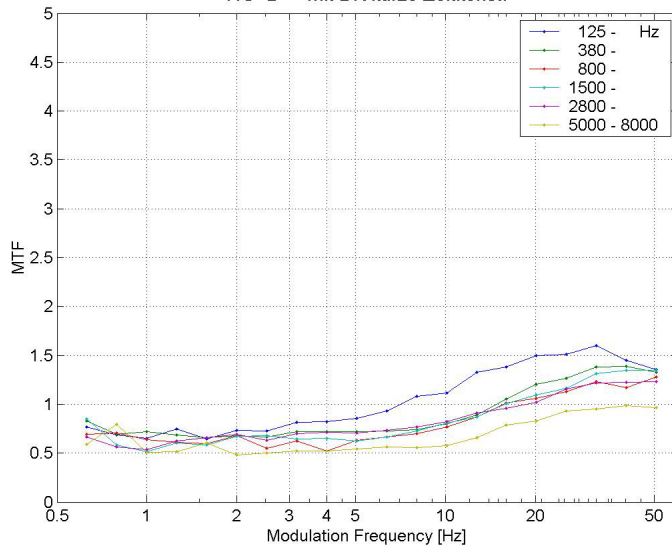
HG B - ohne Dynamikkompression



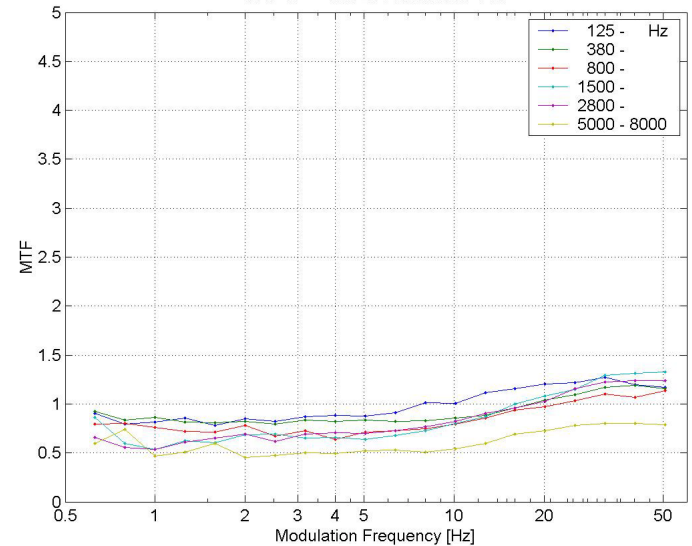
HG B - mit DK lange Zeitkonst.



HG B - mit DK kurze Zeitkonst.



HG B - mit DK variables CR



# Future steps

- Sound recordings of further commercial hearing instruments and master hearing aid
- Refined Analysis:
  - Transition frequencies between channels?
  - Weighting of frequencies and/or modulation frequencies?
  - Phase locked modulations transfer function?
- Speech intelligibility measurements
- Analysis of noise reduction algorithms

# Phase locked MTF

Compression introduces modulations which can be interpreted as an improved SNR by the STI

=> calculate phase-locked modulation transfer function

(Festen and van Dijkhuizen, 1999)

$$\text{MTF}_{\text{PL}} = A * C_{xy}(f) / S_{xx}(f)$$

$C_{xy}(f)$ : Cross-spectral density of input and output envelope

$S_{xx}(f)$ : Auto-spectral density of input envelope

**i.e.: Modulations in the output signal which are not in phase with the modulations of the input signal do not contribute to speech intelligibility**

Thanks !