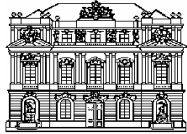


ARI



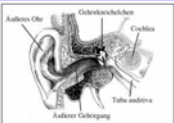
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**Acoustics Research Institute  
Austrian Academy of Sciences**

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# **Limitations on the Perception of Interaural Time Differences in Electric and Acoustic Hearing**

Bernhard Laback, Piotr Majdak, Wolf-Dieter Baumgartner

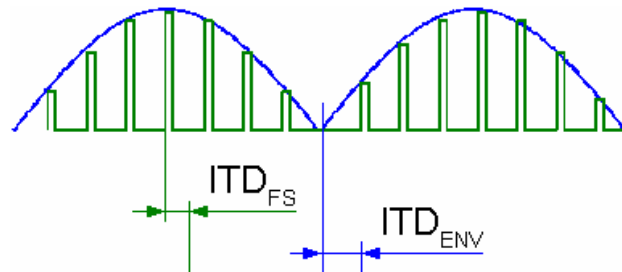




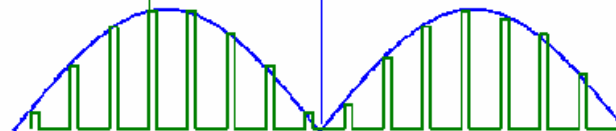
# *Interaural Time Difference (ITD)*

- Interaural time differences (ITDs) are important for the left/right localization of sound sources
- ITDs occur in
  - temporal fine structure (fine pulse timing)
  - temporal envelope

LEFT



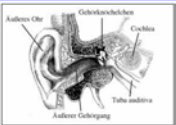
RIGHT





# Overview

- Laback et al. (2005) and Majdak et al. (2005) showed that bilateral CI listeners are sensitive to ITD in the fine structure
  - The “better performing” CI listeners showed significant effects of fine structure ITD for pulse rates up to 800 pps (see next presentation !!!)
  - In addition, normal hearing (NH) subjects were tested, listening to an acoustic simulation of electric stimulation, which uses band-pass filtered clicks (McKay and Carlyon, 1999)
  - The NH subjects showed significant effects up to 400-600 pps
- This study attempted to verify that the performance of the NH listeners was not underestimated by a potentially unfavorable choice of the center frequency (4590 Hz)

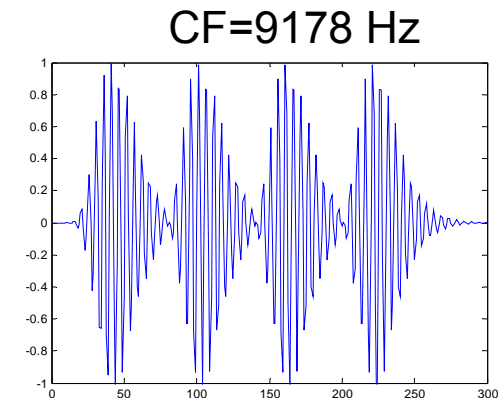
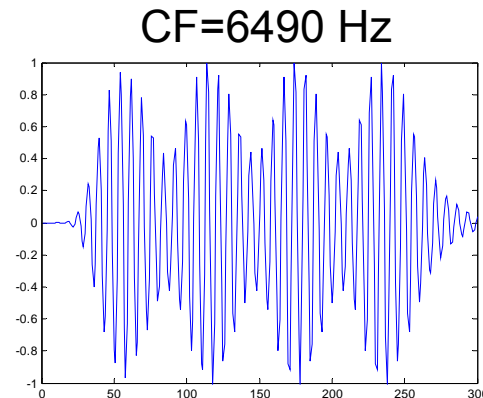
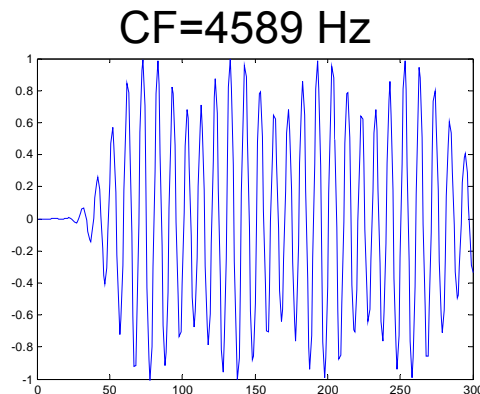




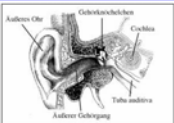
# Hypothesis

*If the ringing of the auditory filters limits ITD perception at higher pulse rates, the maximum pulse rate showing significant effects of ITD will increase with increasing center frequency*

ICI = 1250  $\mu$ s [800 pps]



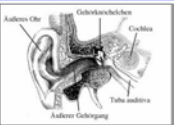
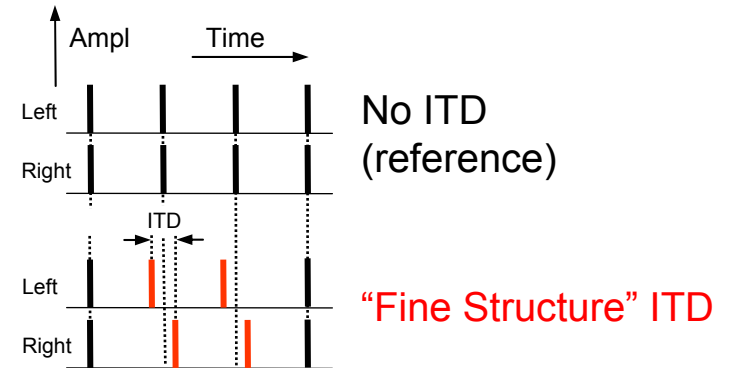
→ Determine the maximum pulse rate showing ITD sensitivity as a function of center frequency (CF)





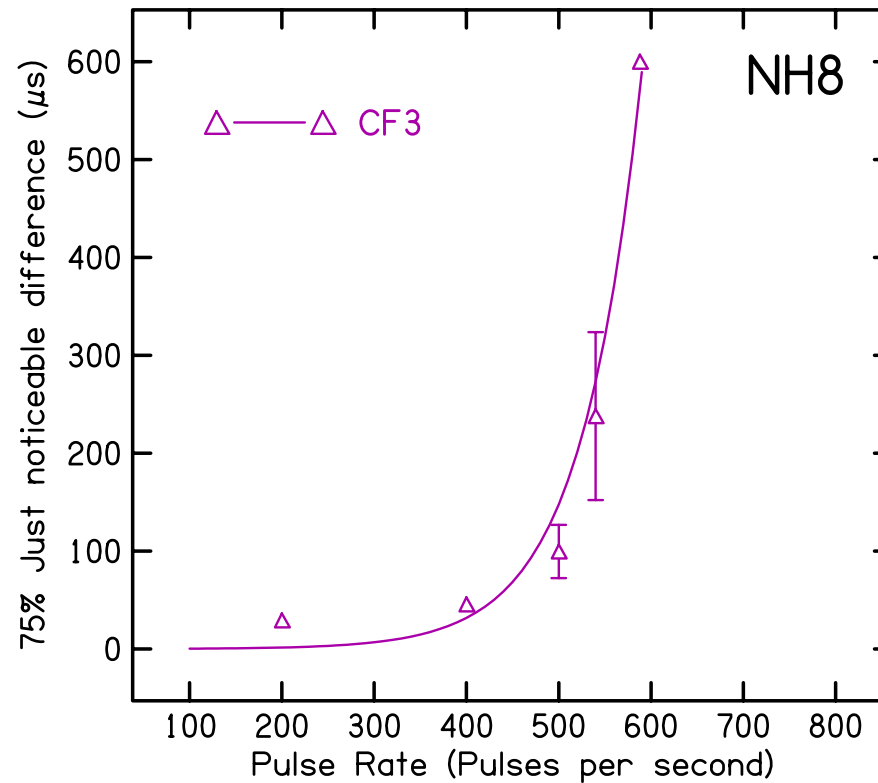
# Experiment Design

- Method
  - Left/Right Discrimination
  - Response feedback
- Subjects: Five NH listeners
- Stimuli: bandpass-filtered click train, 300 ms
- Independent Variables
  - Pulse Rate: 200 ... 800 pps
  - Center frequency of bandpass-filter: 4589, 6490, and 9178 Hz



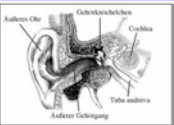


## *Determination of highest pulse rate showing sensitivity*



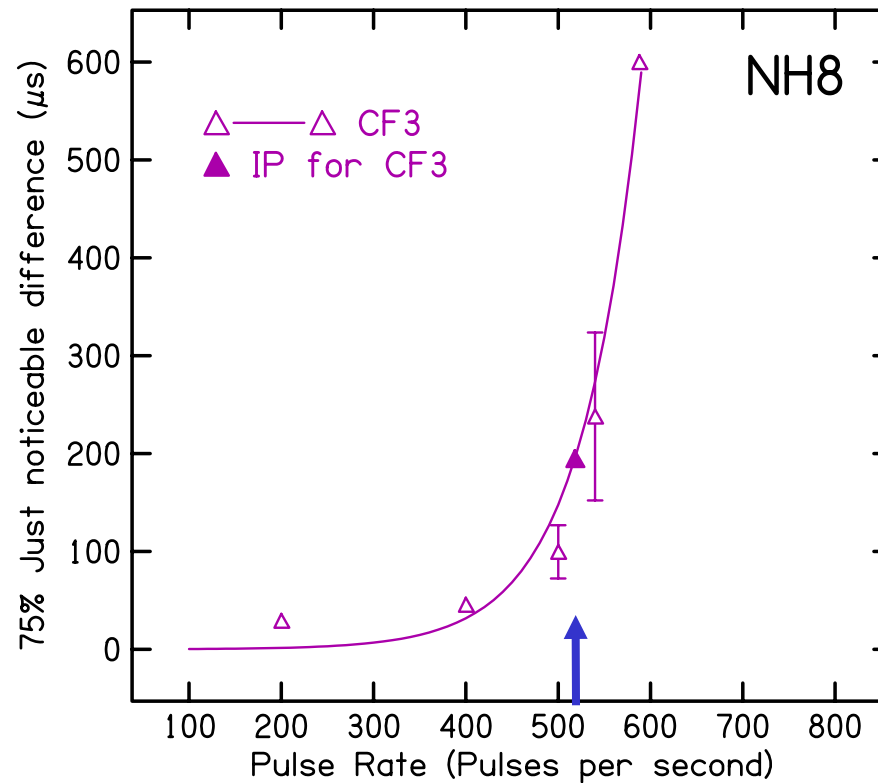
Exponential least-squares fit to the data points

$$y = a * \exp(b * x)$$

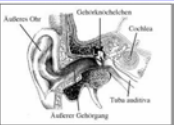




## “Inflection Point”

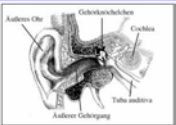
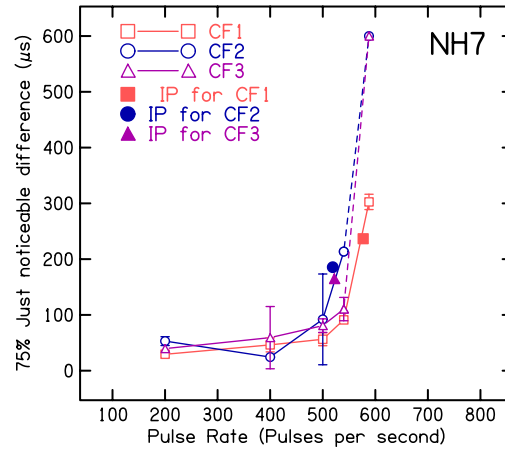
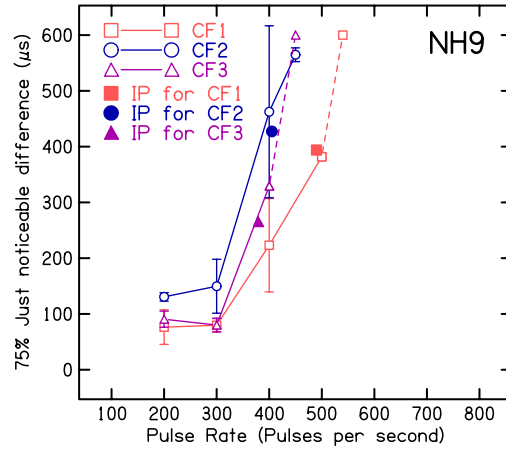
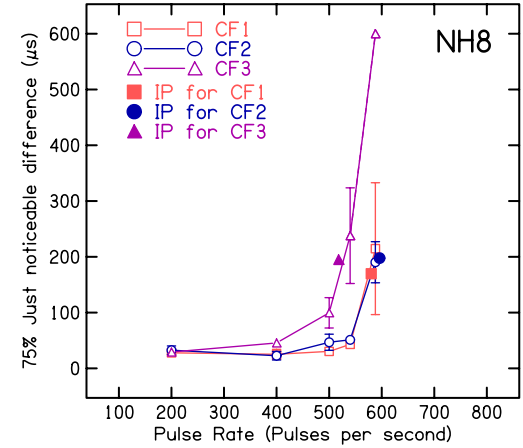
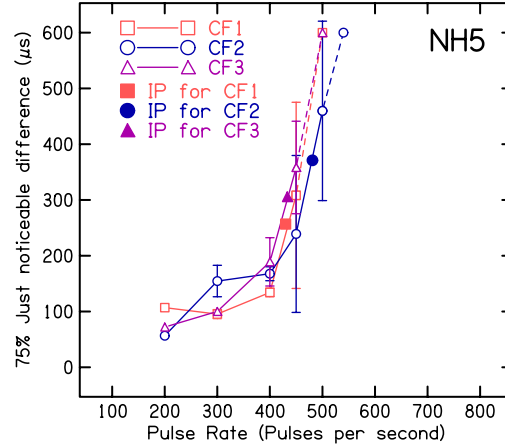
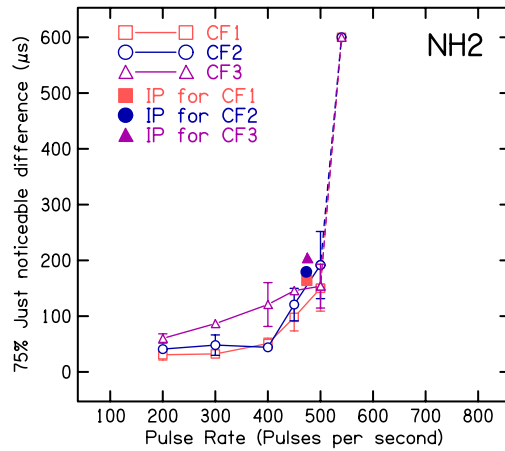


- “Inflection point” = point at which 1st derivative of fitted function reaches a specified value (“3.0”)
- Indicator of pulse rate limit





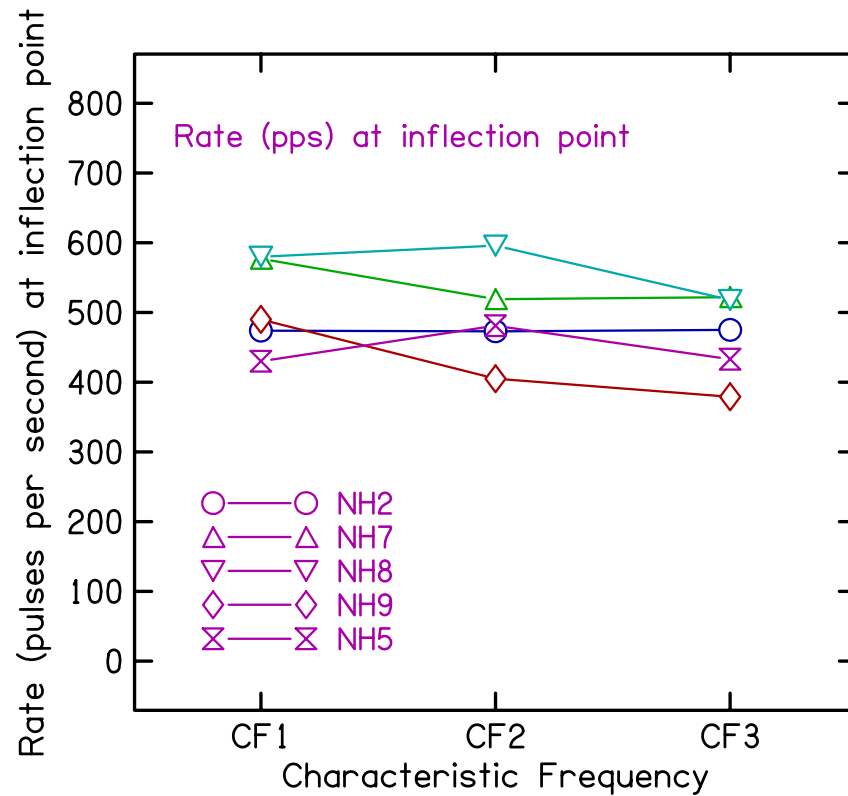
# Results for five subjects







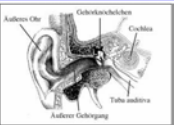
## Effects of CF: individual results



CF1: 4589 Hz

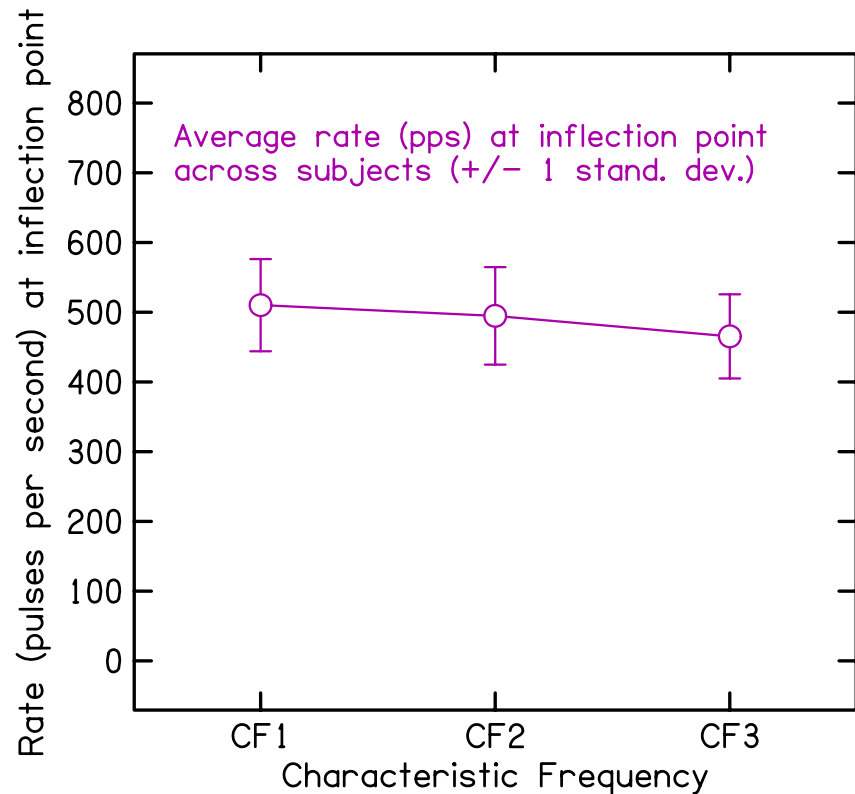
CF2: 6490 Hz

CF3: 9178 Hz





## Effects of CF: average results



CF1: 4.6 kHz

CF2: 6.5 kHz

CF3: 9.2 kHz

### Two-sided $t$ test

- CF1 vs CF2:  $p = 0.568$
- CF1 vs CF3:  $p = 0.104$
- CF2 vs CF3:  $p = 0.129$

Mean across CFs: 490 pps

**No systematic effect of CF!**

