Research Platform 8: initial NRT™ results

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The Nucleus® Research Platform 8 (RP8) is a new research cochlear implant system under investigation in a small number of centres:

- Department of Otorhinolaryngology, University Hospital, Zürich, Switzerland.
- Department of Otolaryngology, Medical University of Hannover, Germany.
- Department of Otolaryngology, Head and Neck Surgery, University of Iowa, Iowa City, Iowa, USA.
- Department of Otolaryngology, New York University Medical Center, NY, USA.
- Department of Otolaryngology-Head and Neck Surgery, Washington University School of Medicine, St Louis, MO, USA.
- Cooperative Research Centre for Cochlear Implant and Hearing Aid Innovation, Melbourne and Sydney, Australia.
- Sydney Cochlear Implant Centre, Sydney, Australia.

There are a number of enhanced NRT features of the RP8 system:

- Improved NRT amplifier linearity, symmetry and saturation recovery.
- Inbuilt artefact suppression features.
- Fine gain adjustments: 40, 50, 60, 70 dB.
- NRT sample rate: 20,000 samples per second, oversampling up to 200.000 samples per second.
- A larger memory buffer for storing data, with sample windows of 16, 32 or 64 samples per sweep.

The early findings have been very encouraging. First, the noise floor of the NRT amplifier is about 10 times better than that with the existing system. Figure 1 shows the noise floor as a function of the number of sweeps. These were calculated by measuring the standard deviation of the last eight samples of NRT traces. At one sweep, the noise floor is only 3 µV, reducing to less than 1.5 µV by 10 sweeps.

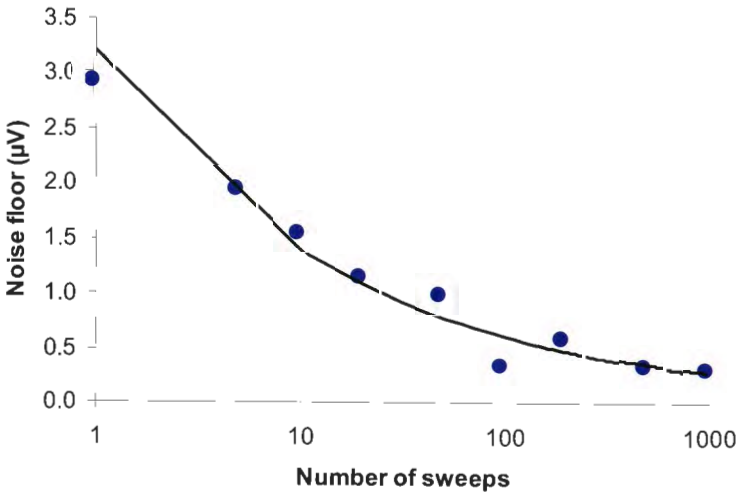

Figure 1 The very low NRT amplifier noise floor of the RP8 system as a function of the number of sweeps.

Second, in addition to the standard forward masking paradigm there are three new approaches to artefact cancellation and reduction: a third phase or triphasic pulse, alternating polarity, and artefact template. Figure 2 shows a comparison of the different paradigms from one subject. While there are differences in the shape of the waveforms, these early findings suggest that these paradigms may provide an alternate and quicker approach to the forward masking paradigm with further development.

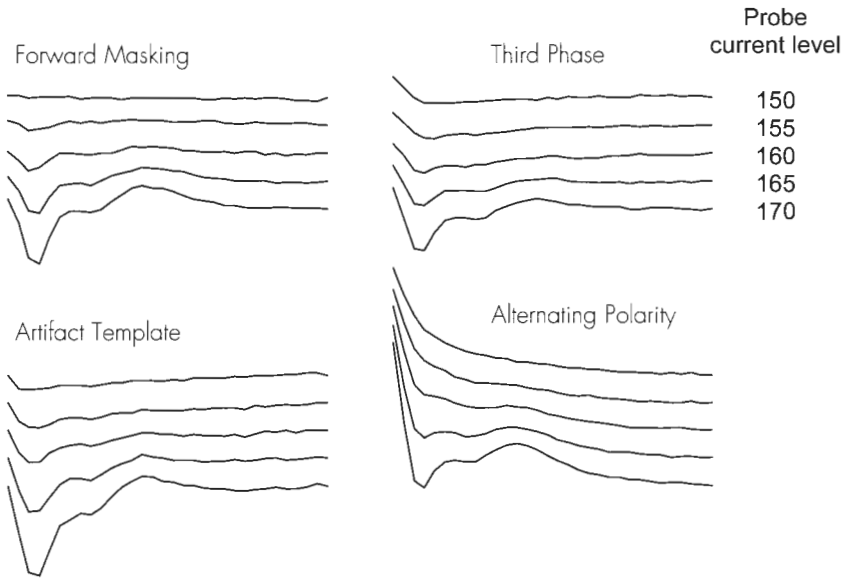

Figure 2 Results from one subject showing the different artefact cancellation and reduction paradigms

Third, it is now possible to measure changes in ECAP (N1-P1) amplitude as a result of stimulation at different rates. This could provide an indirect measure of neural adaptation and may be useful in selecting the ACE™ stimulation rate. Figure 3 shows the average changes in ECAP amplitude as a function of probe rates from a group of seven subjects.

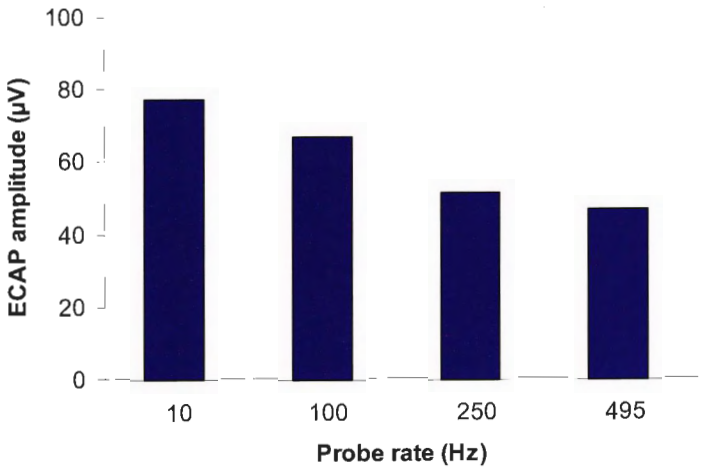

Figure 3 Average results (n=7) showing the reduction in ECAP amplitude as a function of probe stimulation rate.

Overall, these early results with the RP8 system show that more reliable, faster and easier NRT recordings will be possible in the next generation of the Nucleus cochlear implant system.

Research Platform 8: Initial NRT Results

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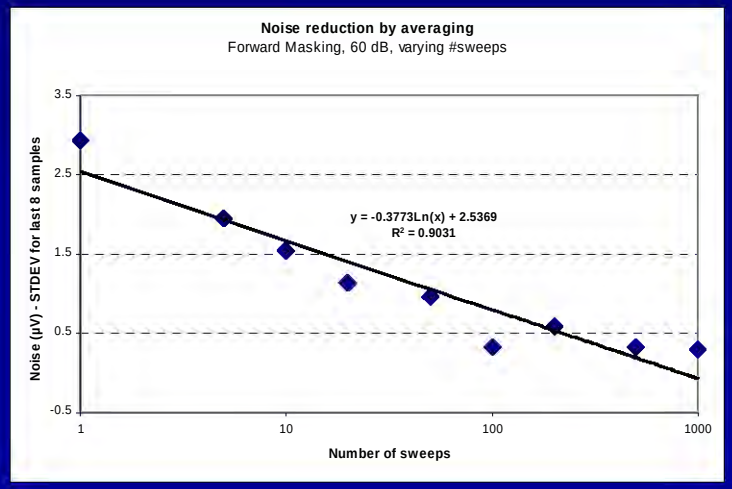
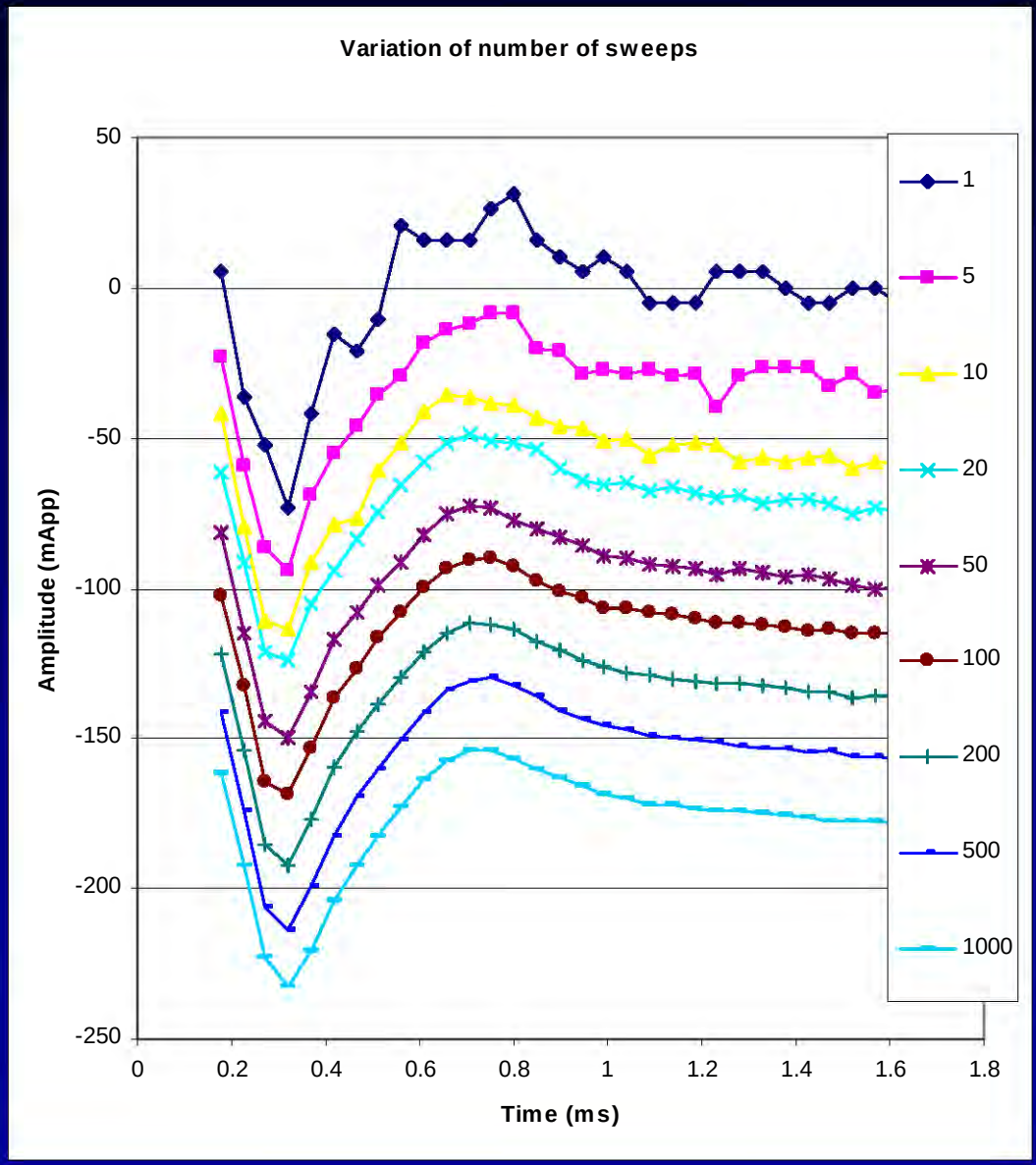
Research Platform (RP8)

- Improved NRT amplifier linearity, symmetry and saturation recovery
- Inbuilt artifact suppression features.
- Fine gain adjustments: 40, 50, 60, 70 dB
- NRT sample rate: 20,000 samples per second, oversampling up to 200.000 samples per second.
- Sample windows: 16, 32 or 64 samples per sweep.

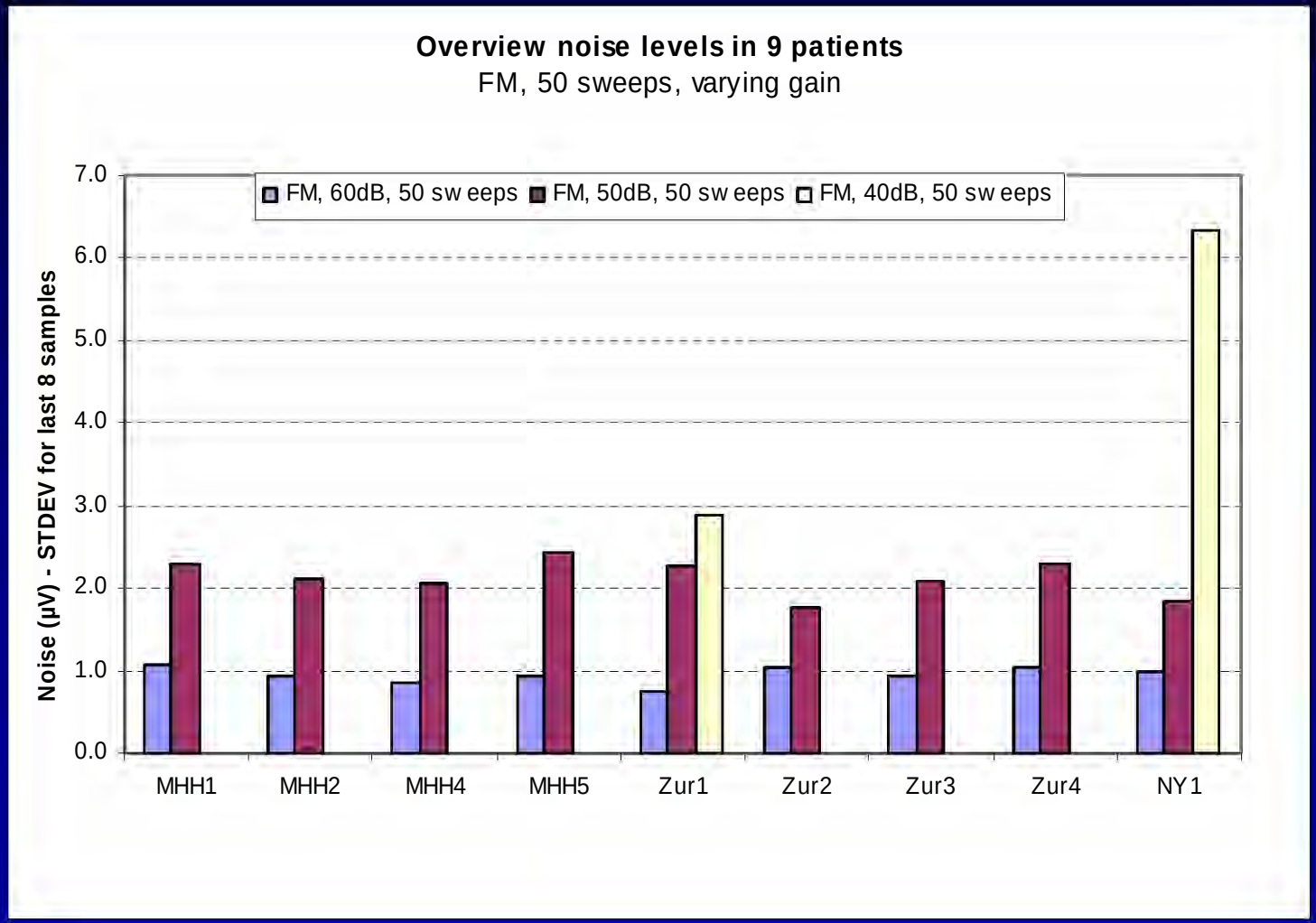
Variation of number of averaged sweeps

Noise level vs. number of sweeps

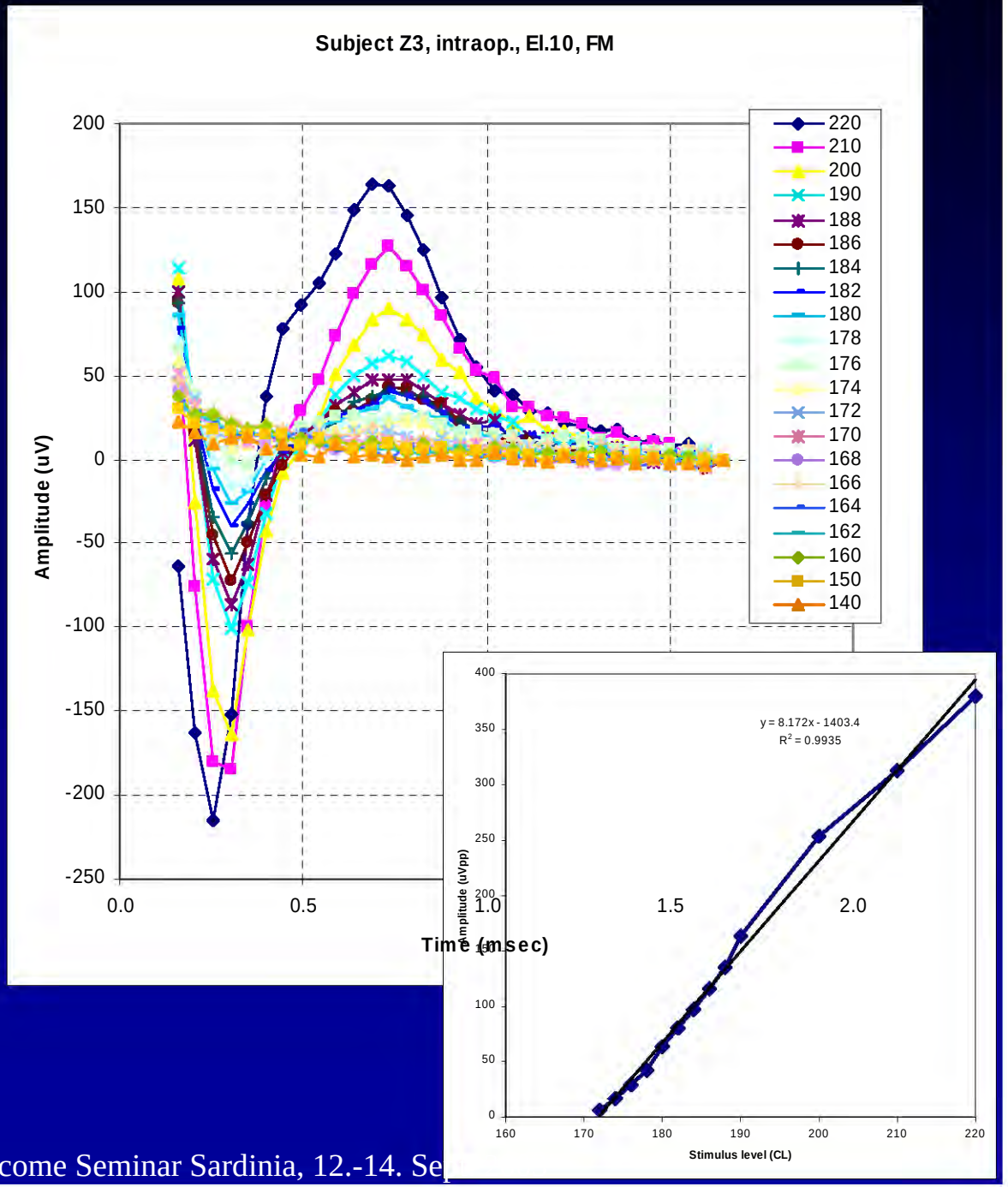




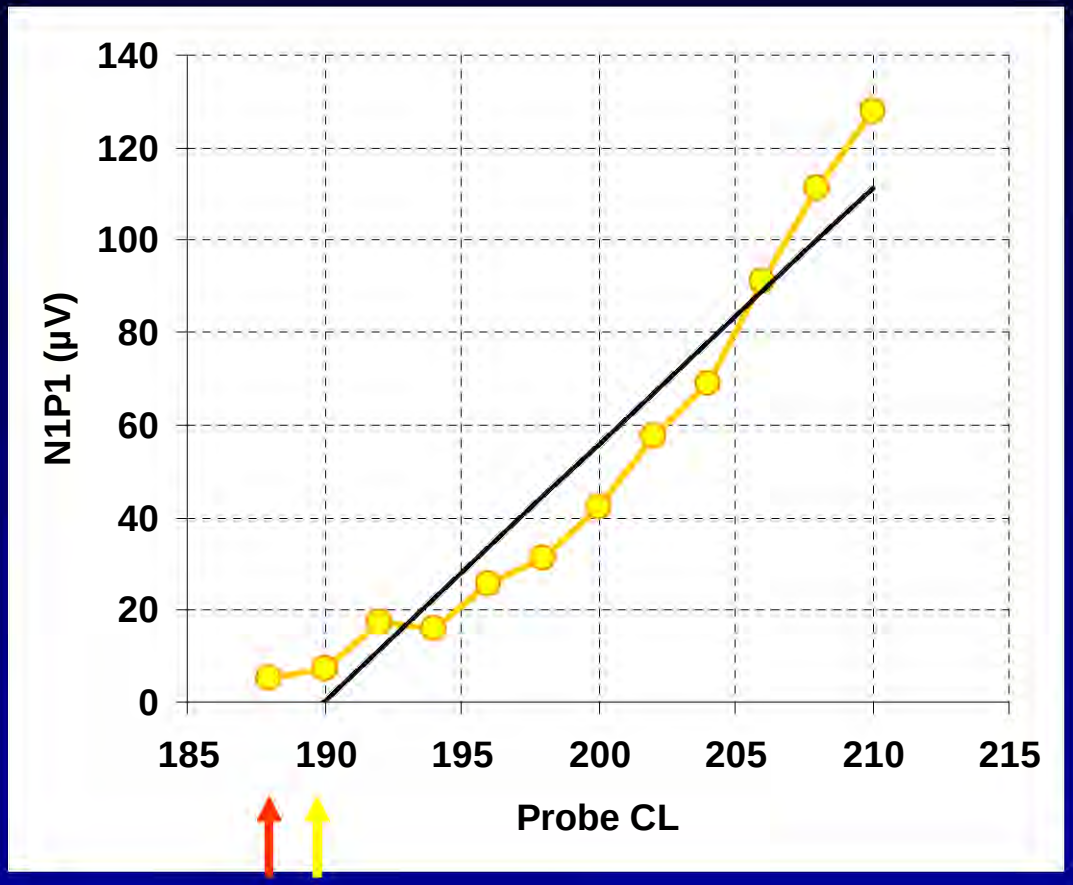
Calculated noise levels (9 subjects)

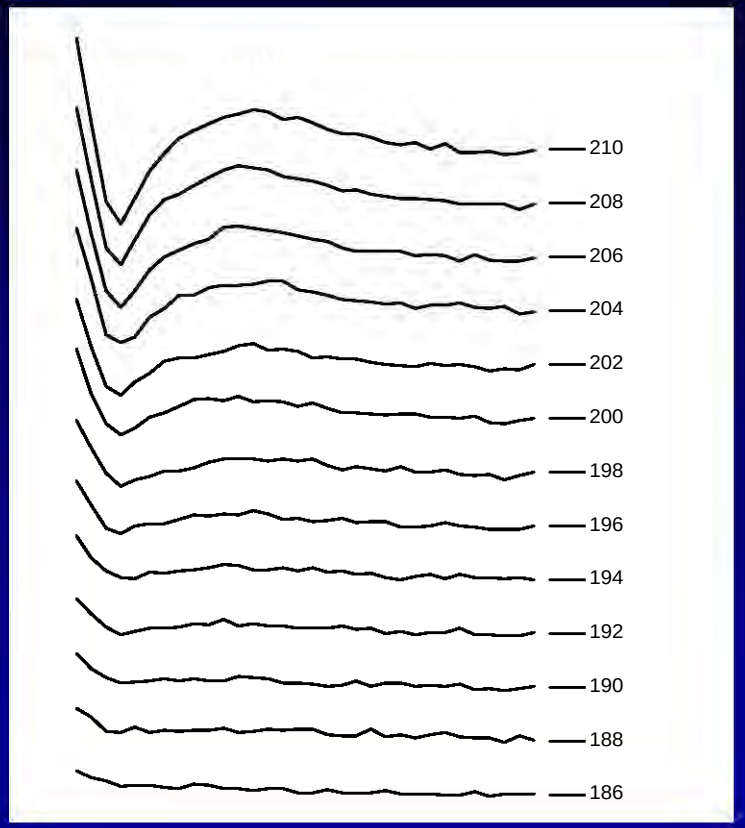


Intraoperative estimation of NRT thresholds (T-NRT)



AGF & T-NRT

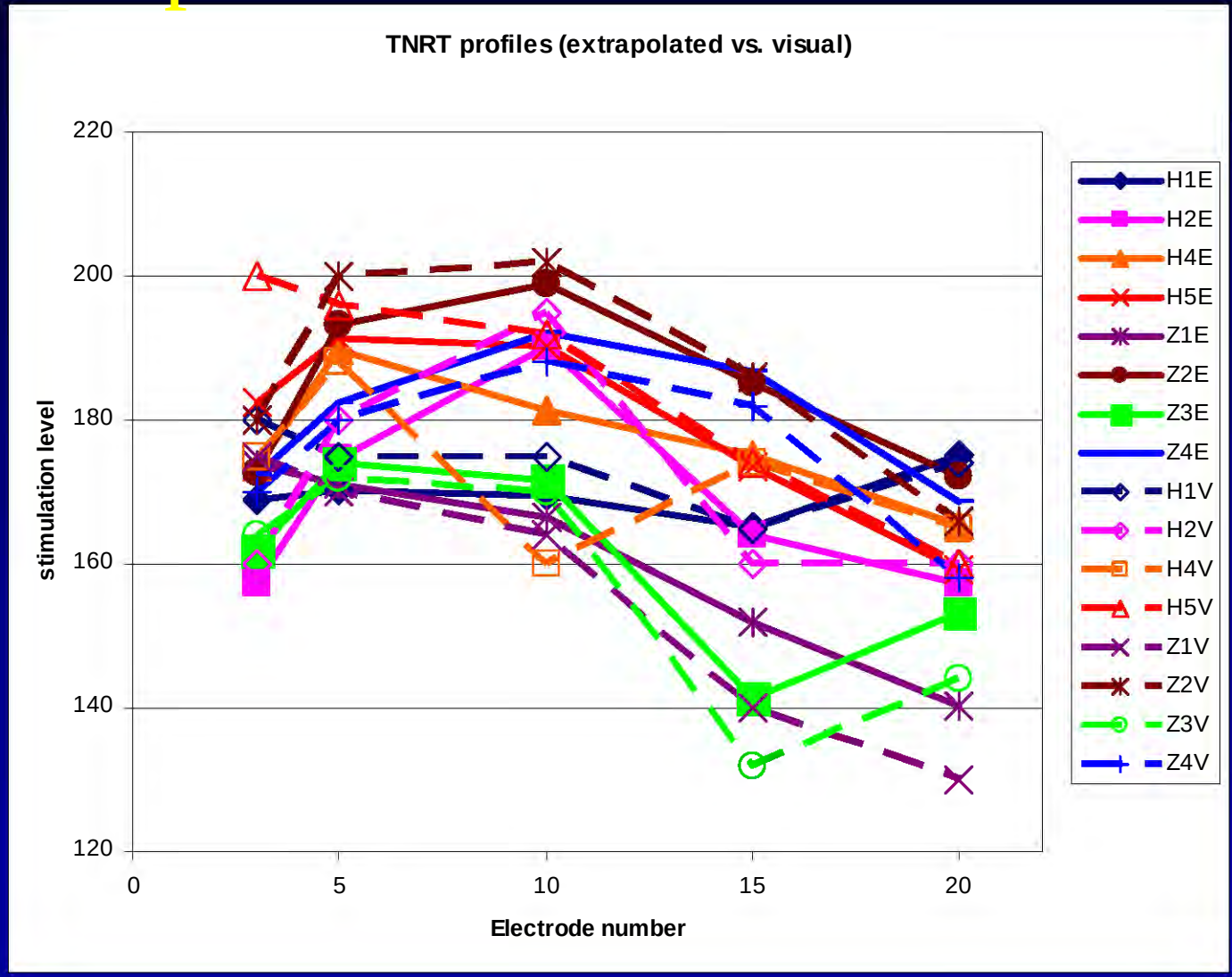




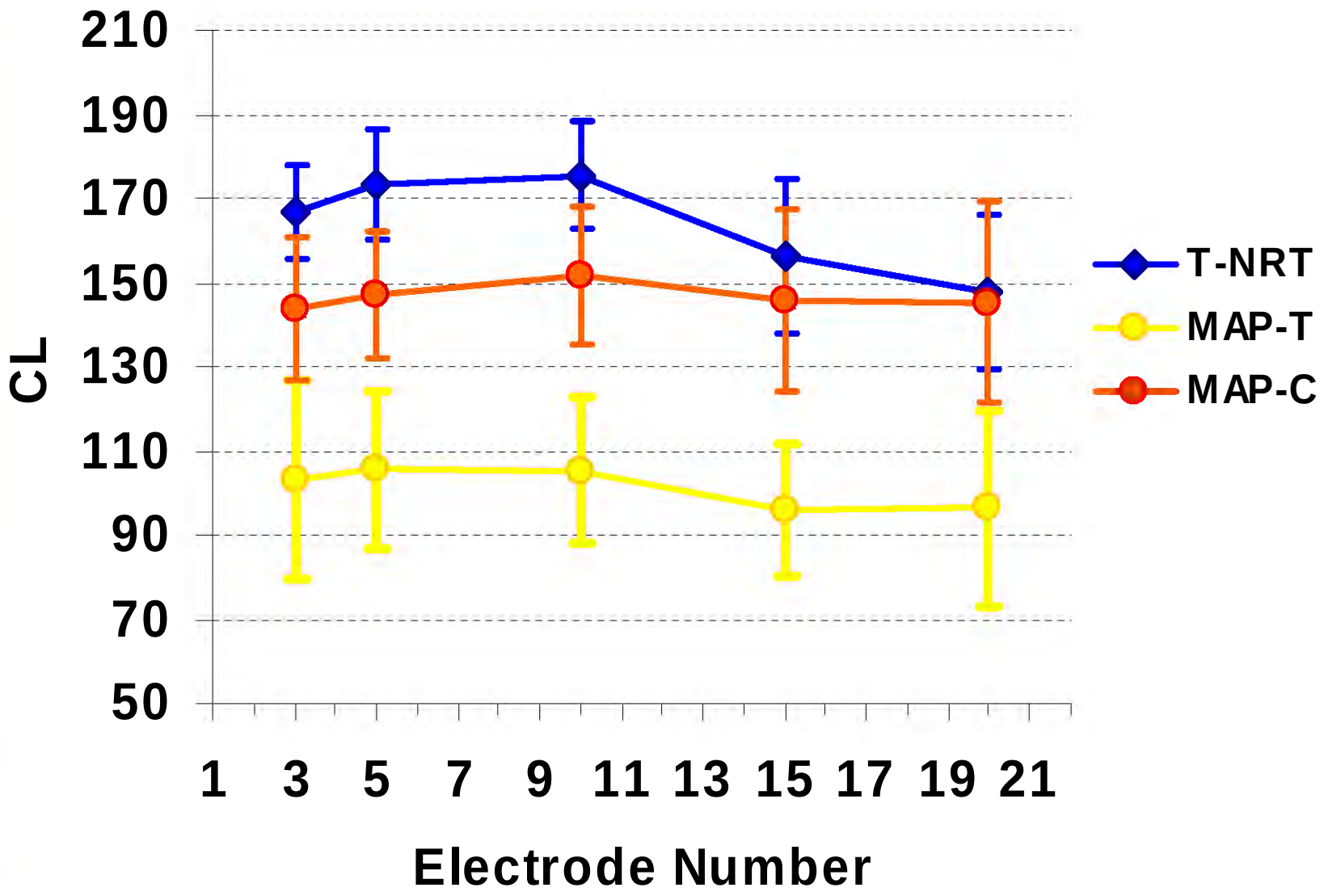
Visual T-NRT = 188

Extrapolated T-NRT =190

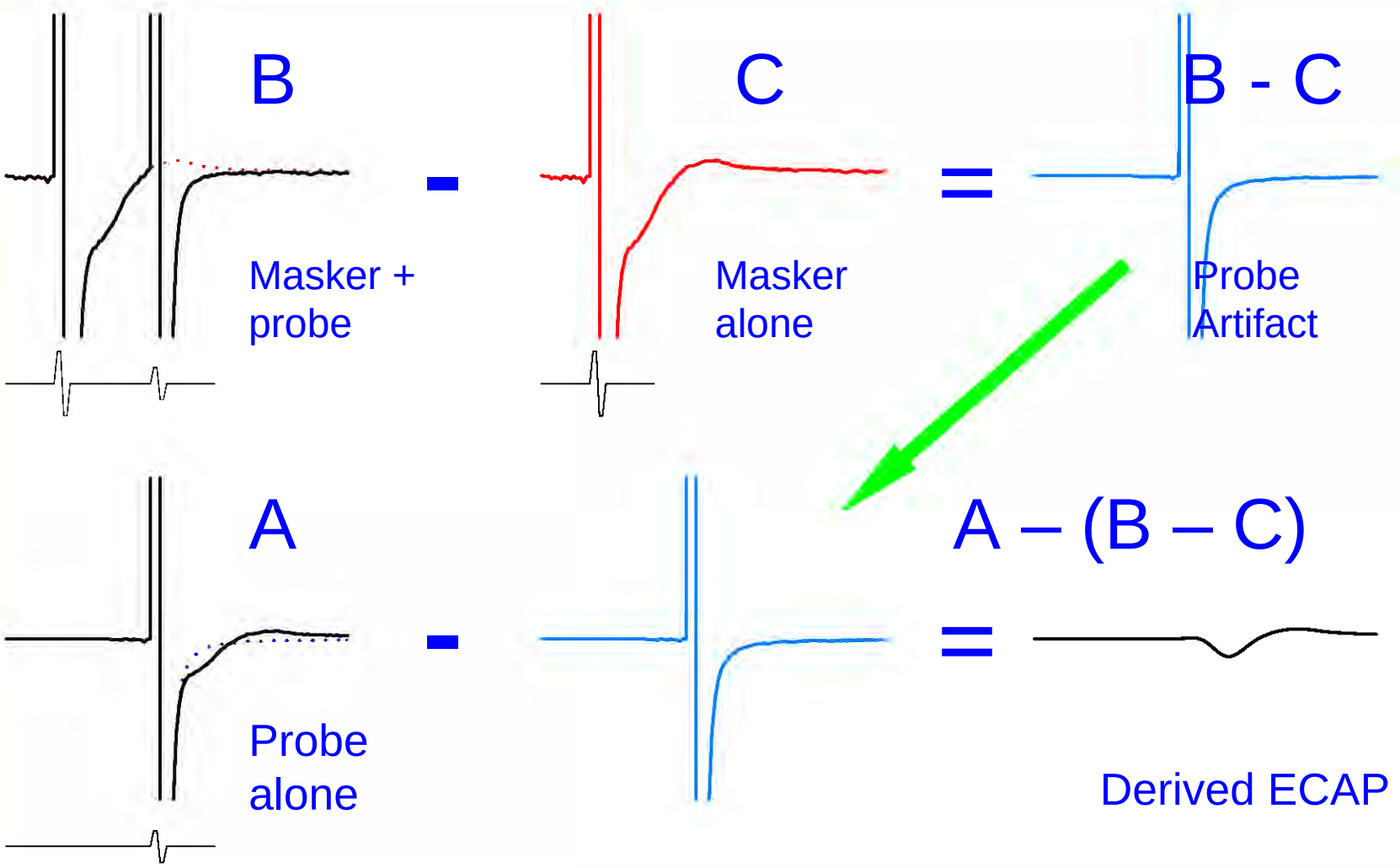
TNRT profiles (8 subjects, extrapolation and visual detection)



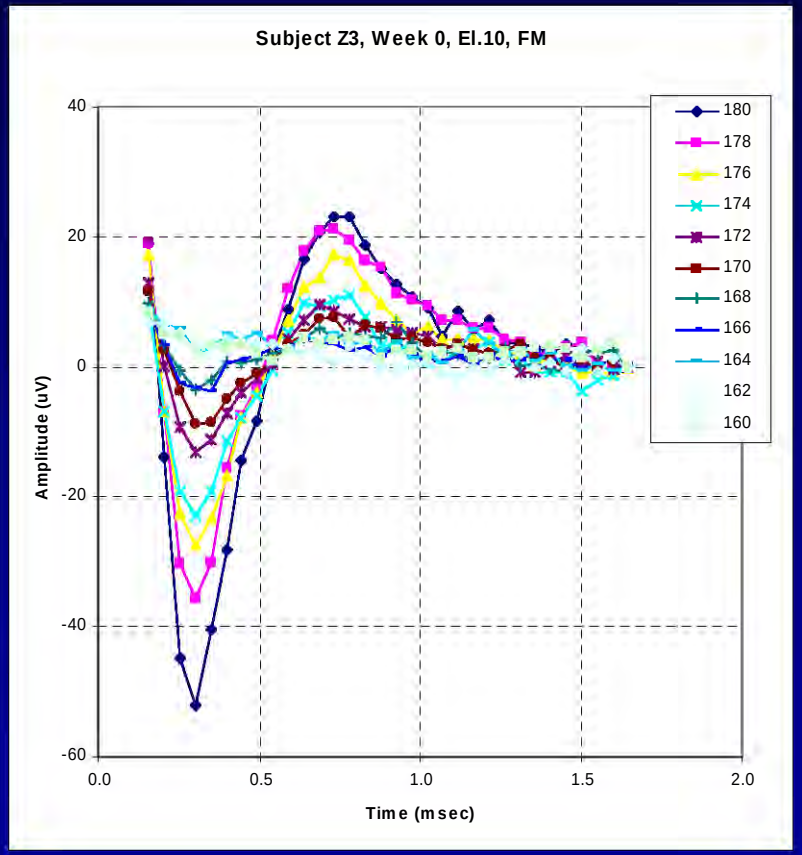
T-NRT, MAP-T & MAP-C level

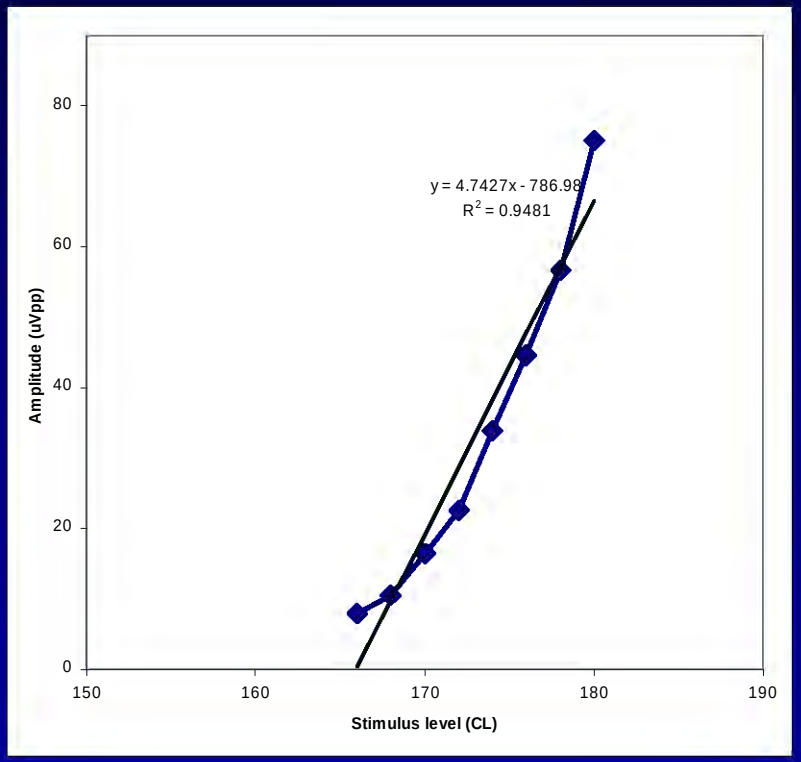


Cancellation by masking

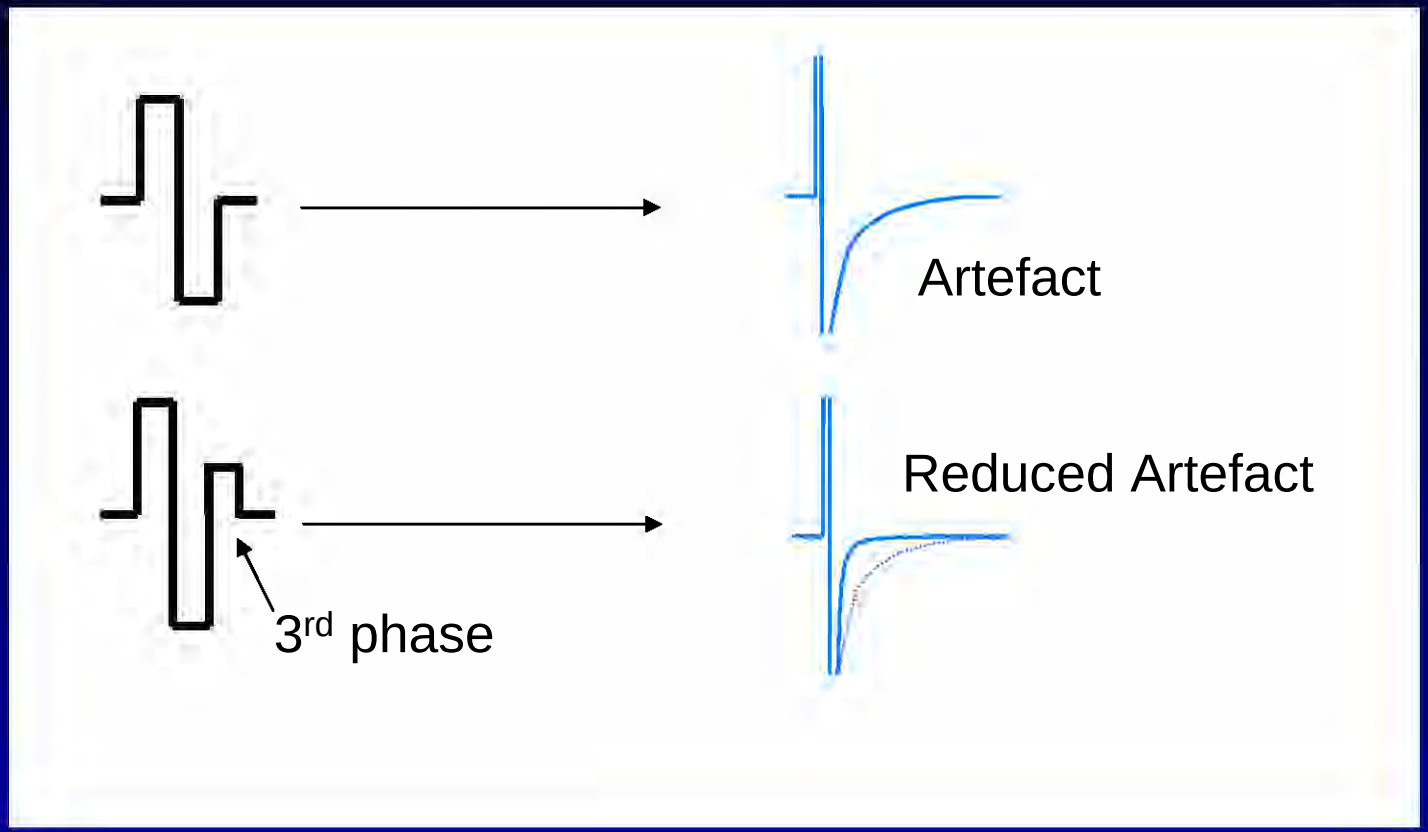


Artifact cancellation with Forward Masking (subtraction paradigm)



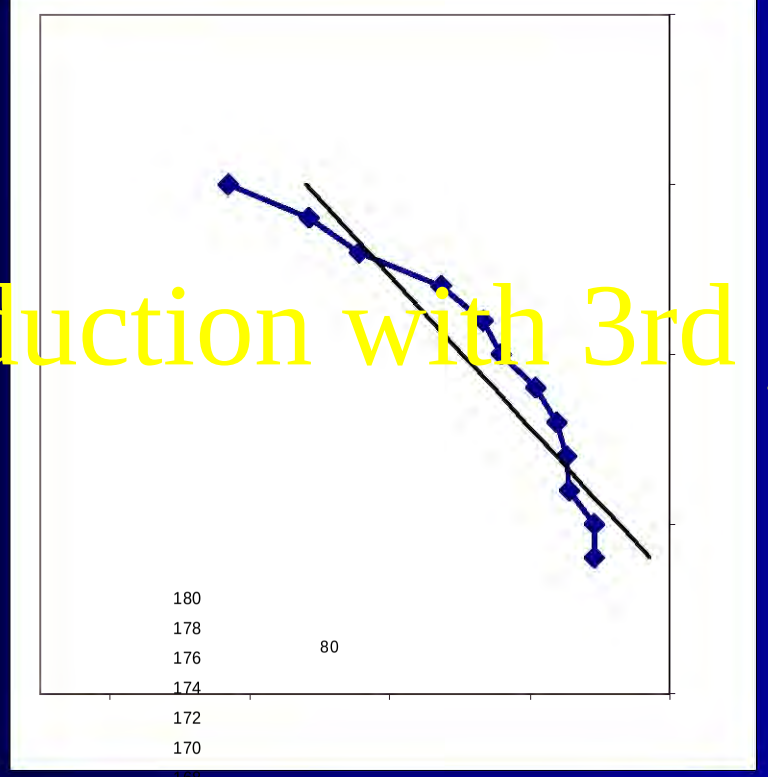


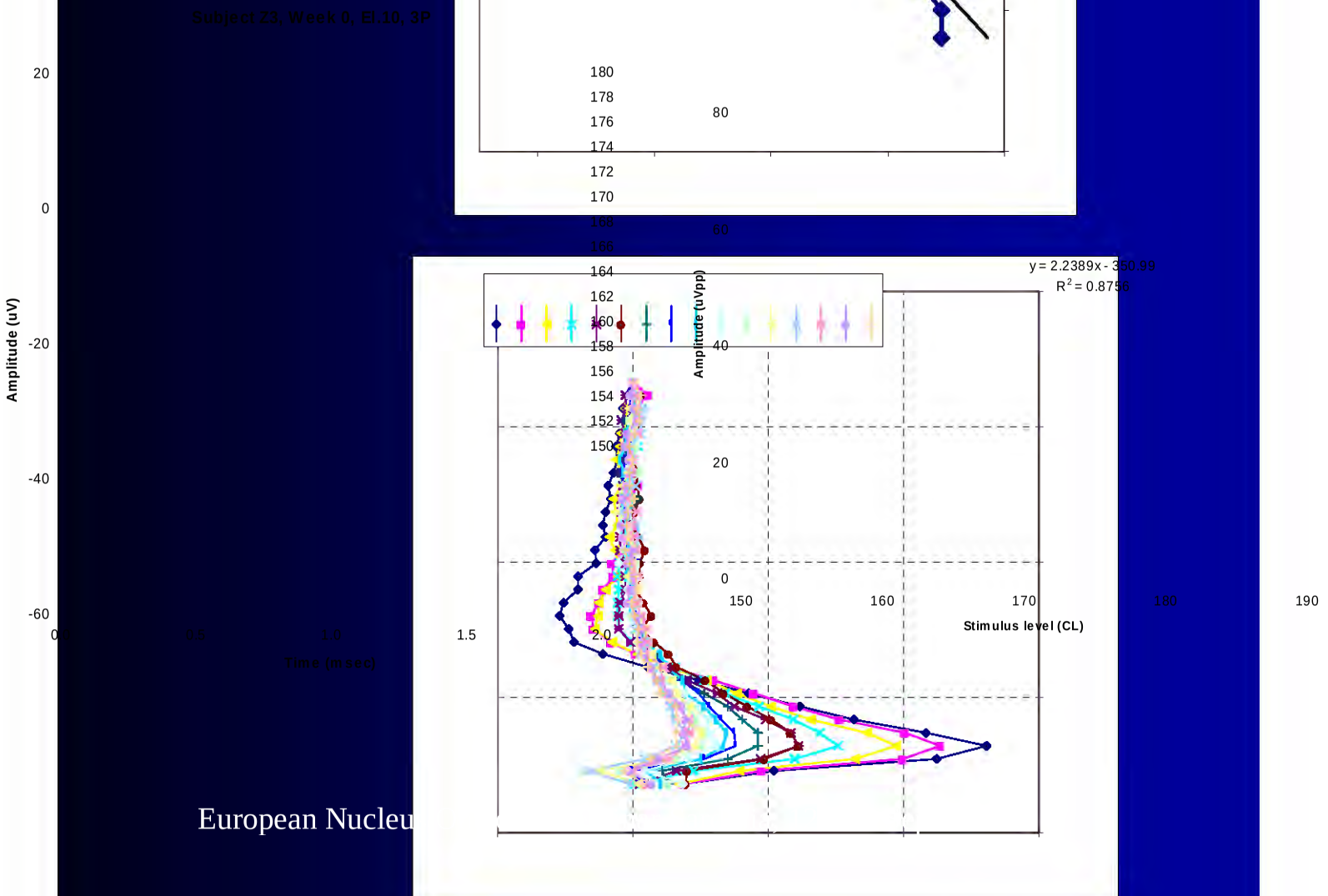
Artifact Reduction: triphasic pulse



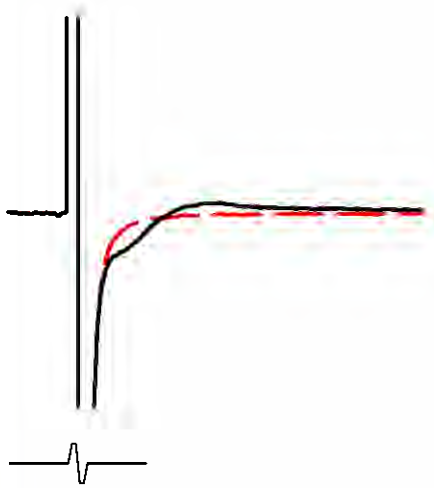
(Can be combined with all other techniques)

Artifact reduction with 3rd phase

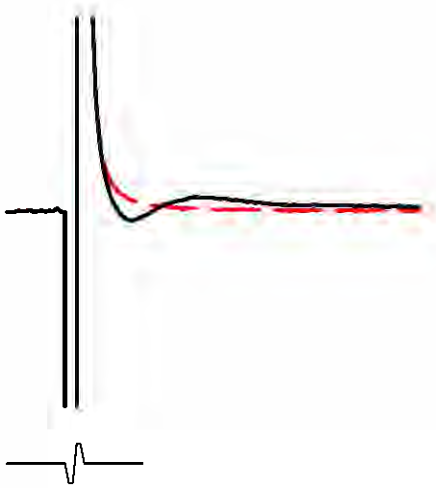




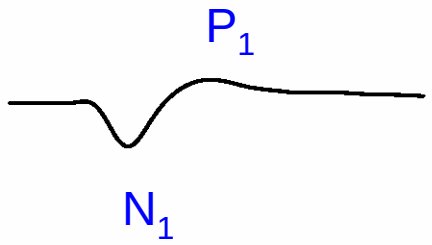
Cancellation by alternating polarity



Anodic
leading

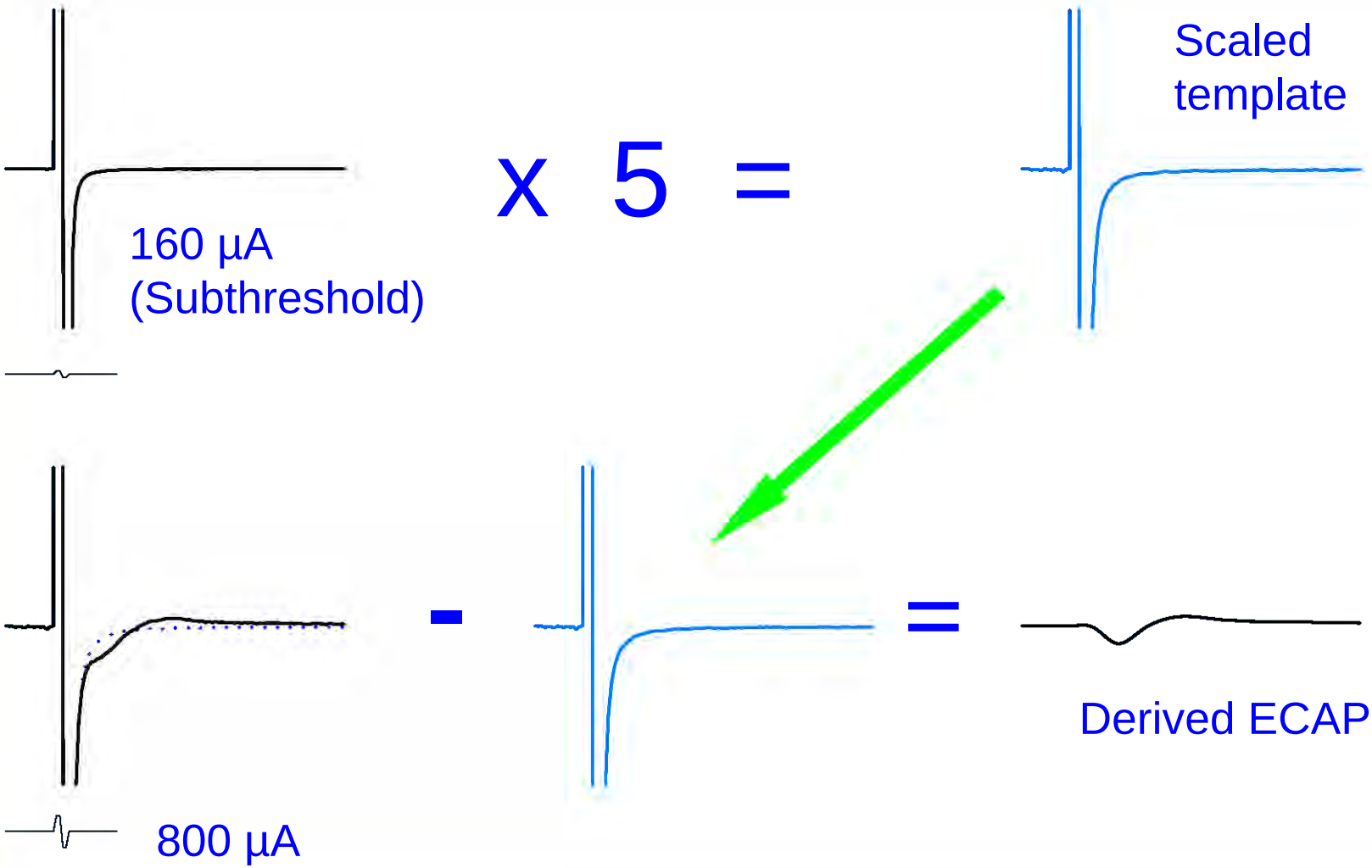


Cathodic
leading

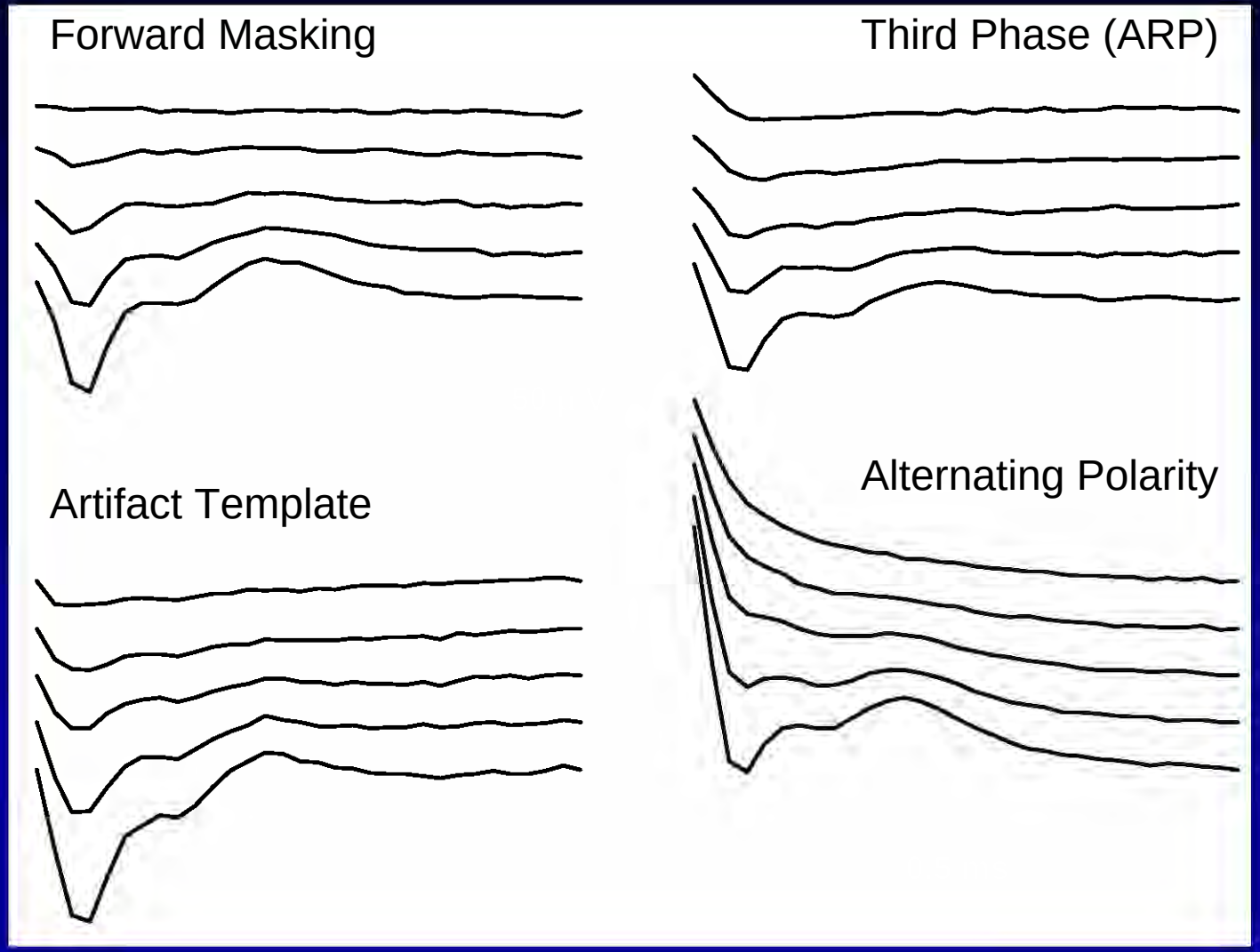


Summed ECAP
(2x)

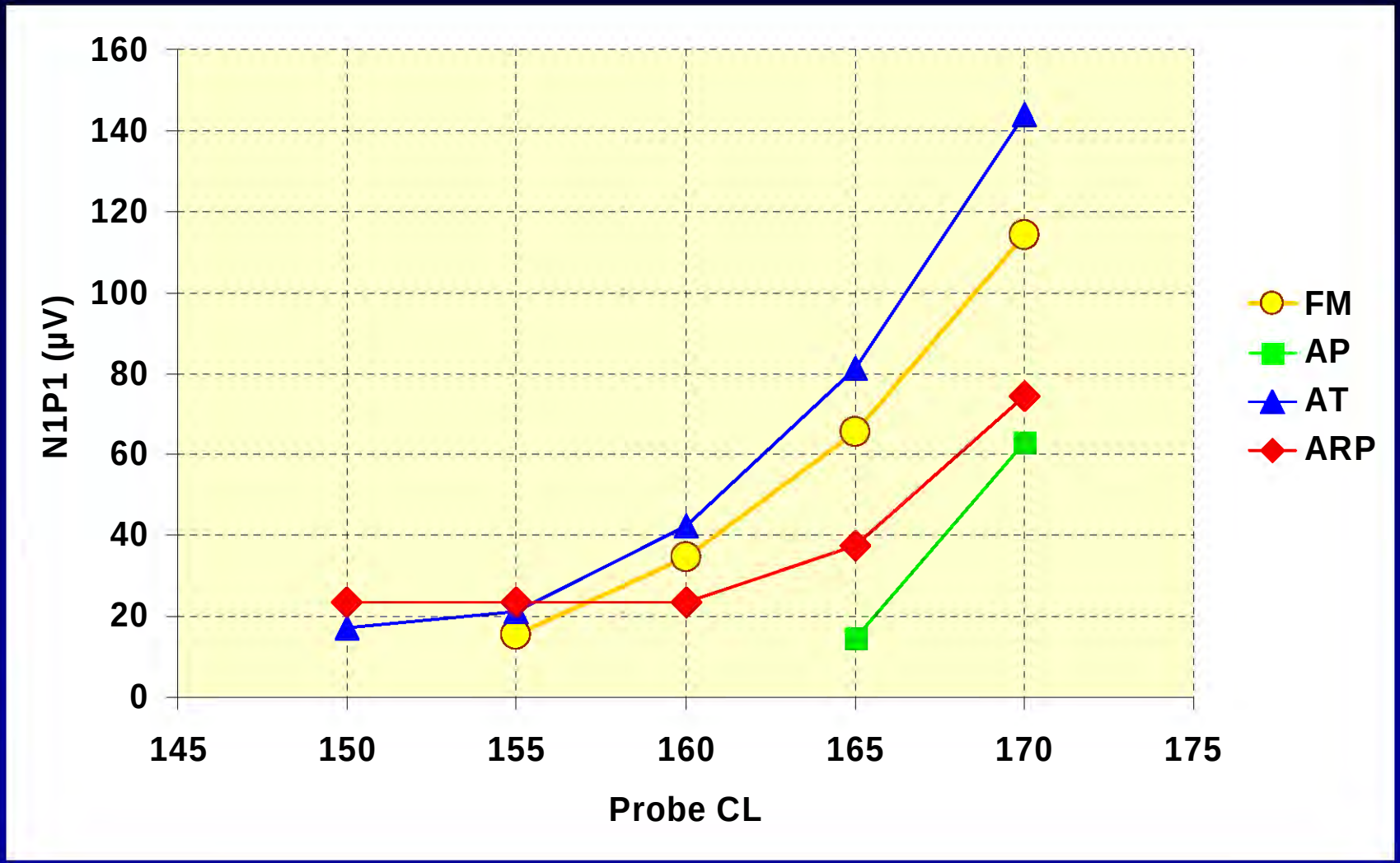
Cancellation by scaled template



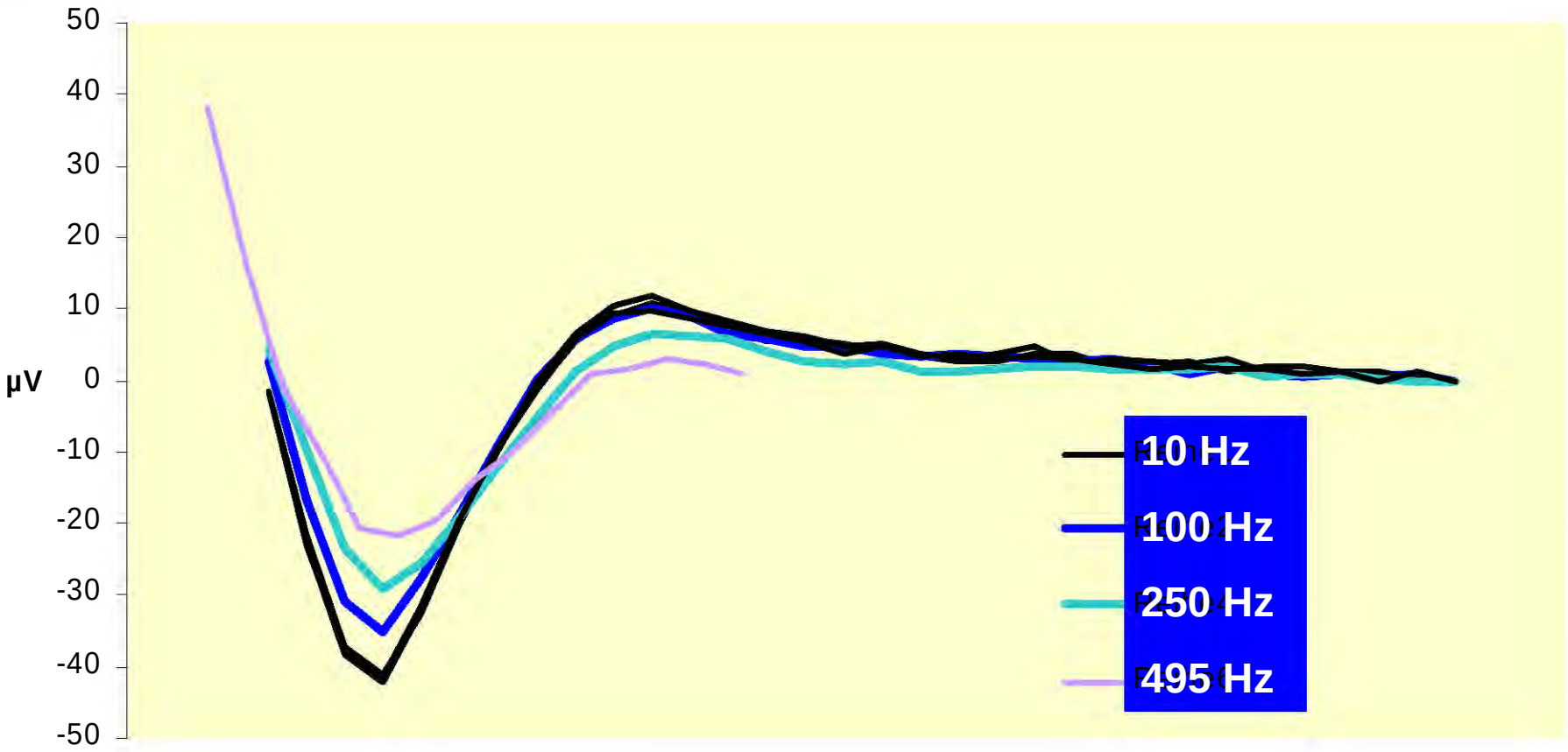
Artefact Cancellation/Reduction



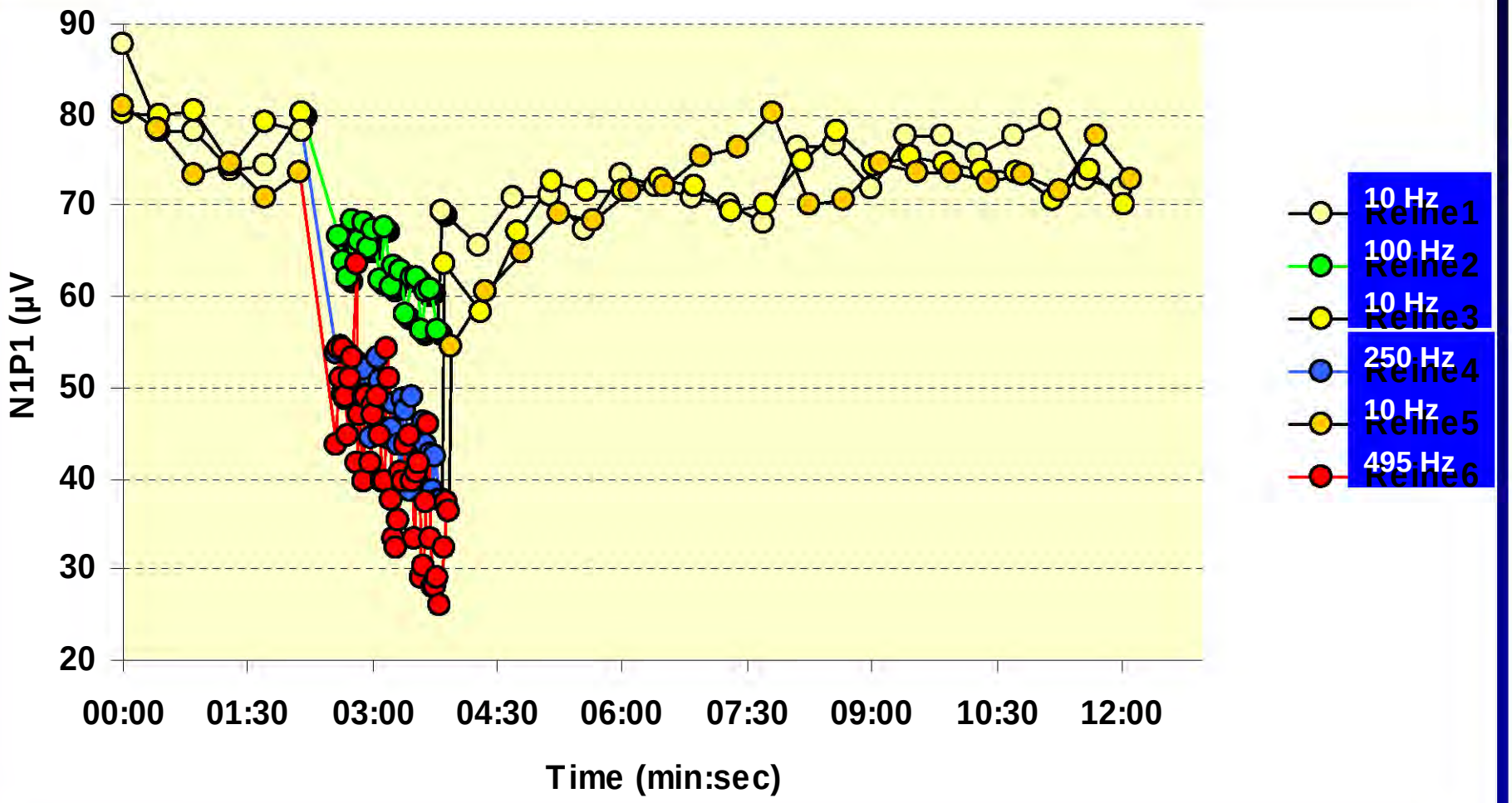
Artefact Cancellation/Reduction



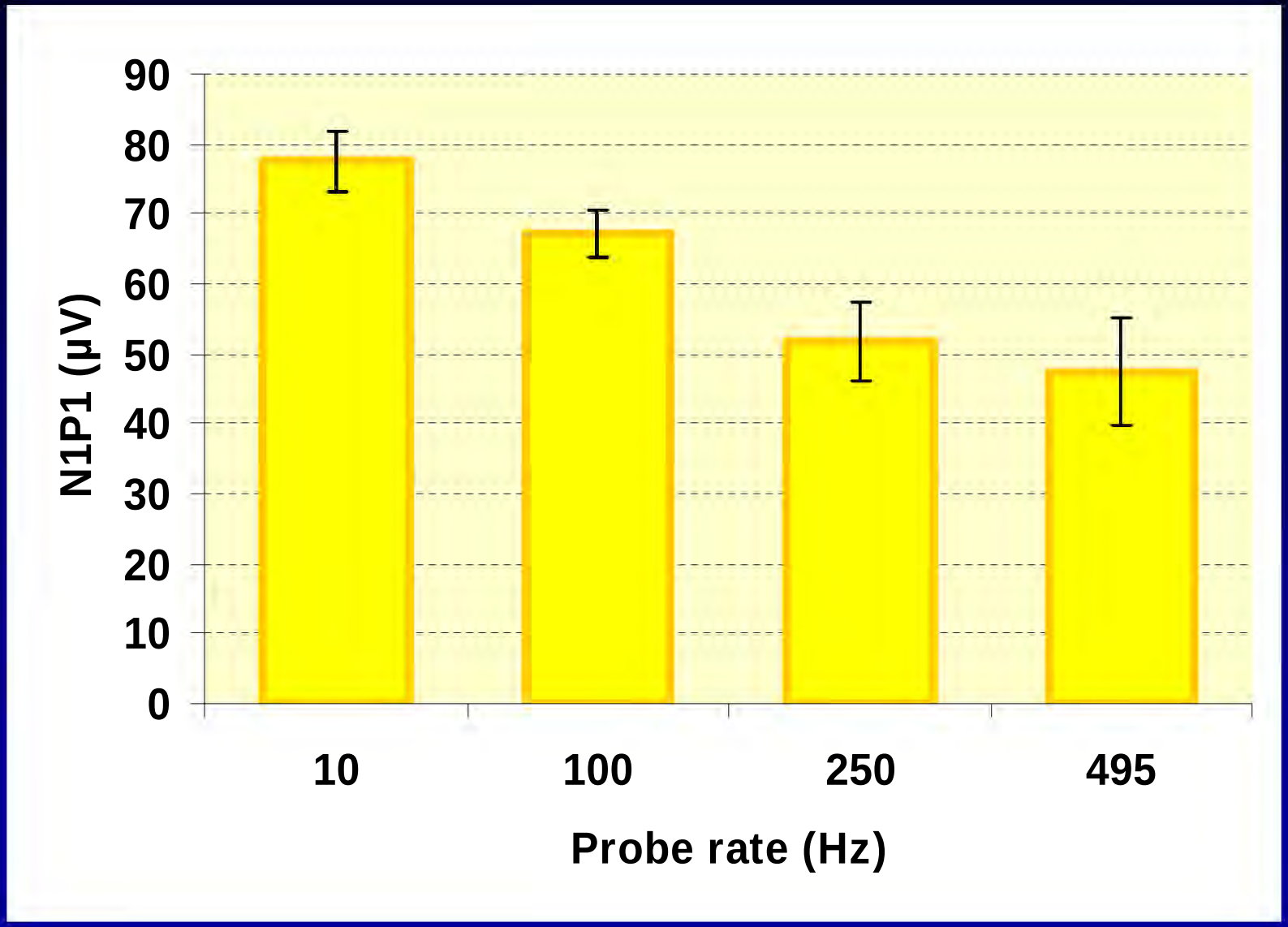
Rate Adaptation (traces)



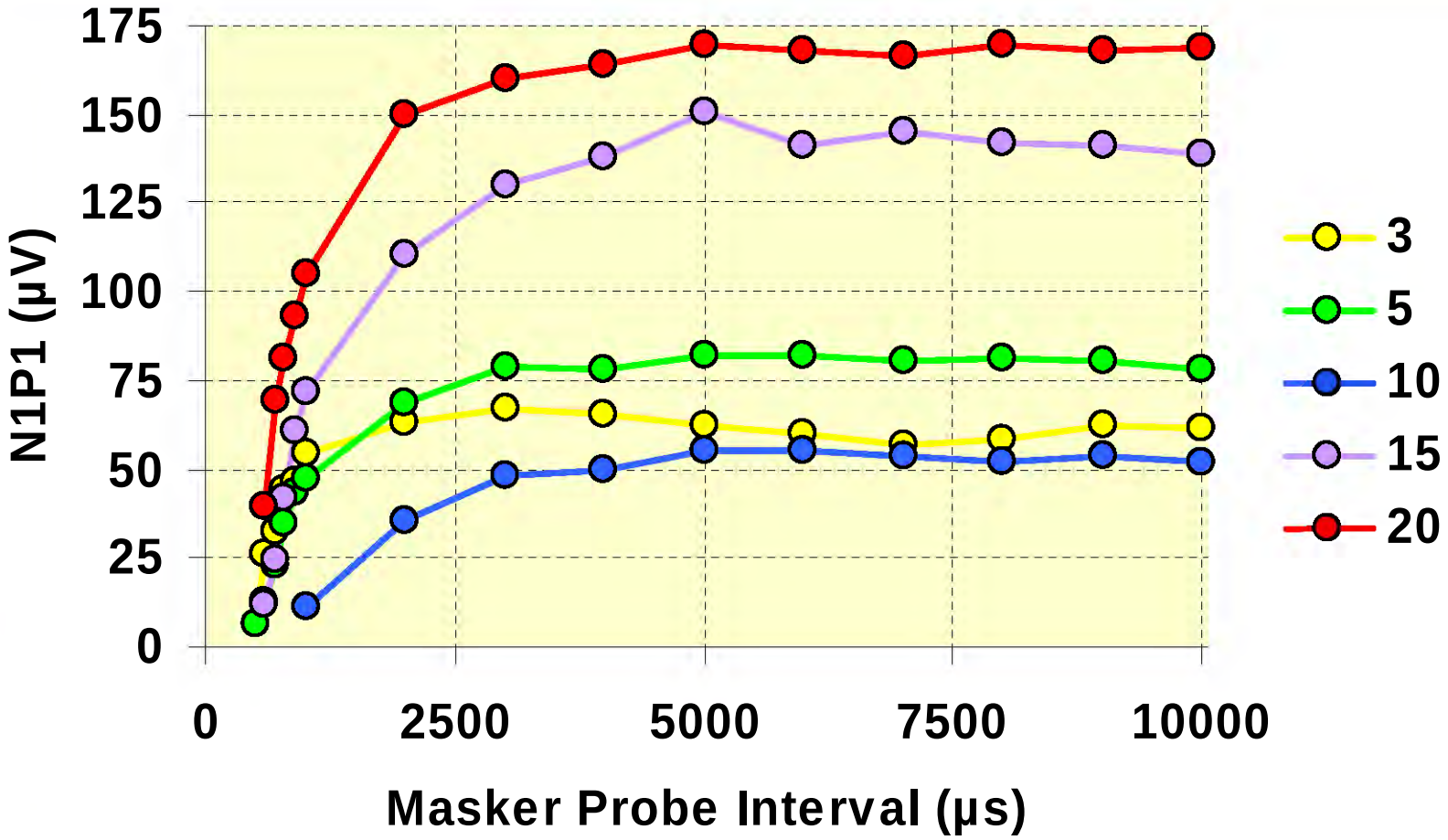
Rate Adaptation



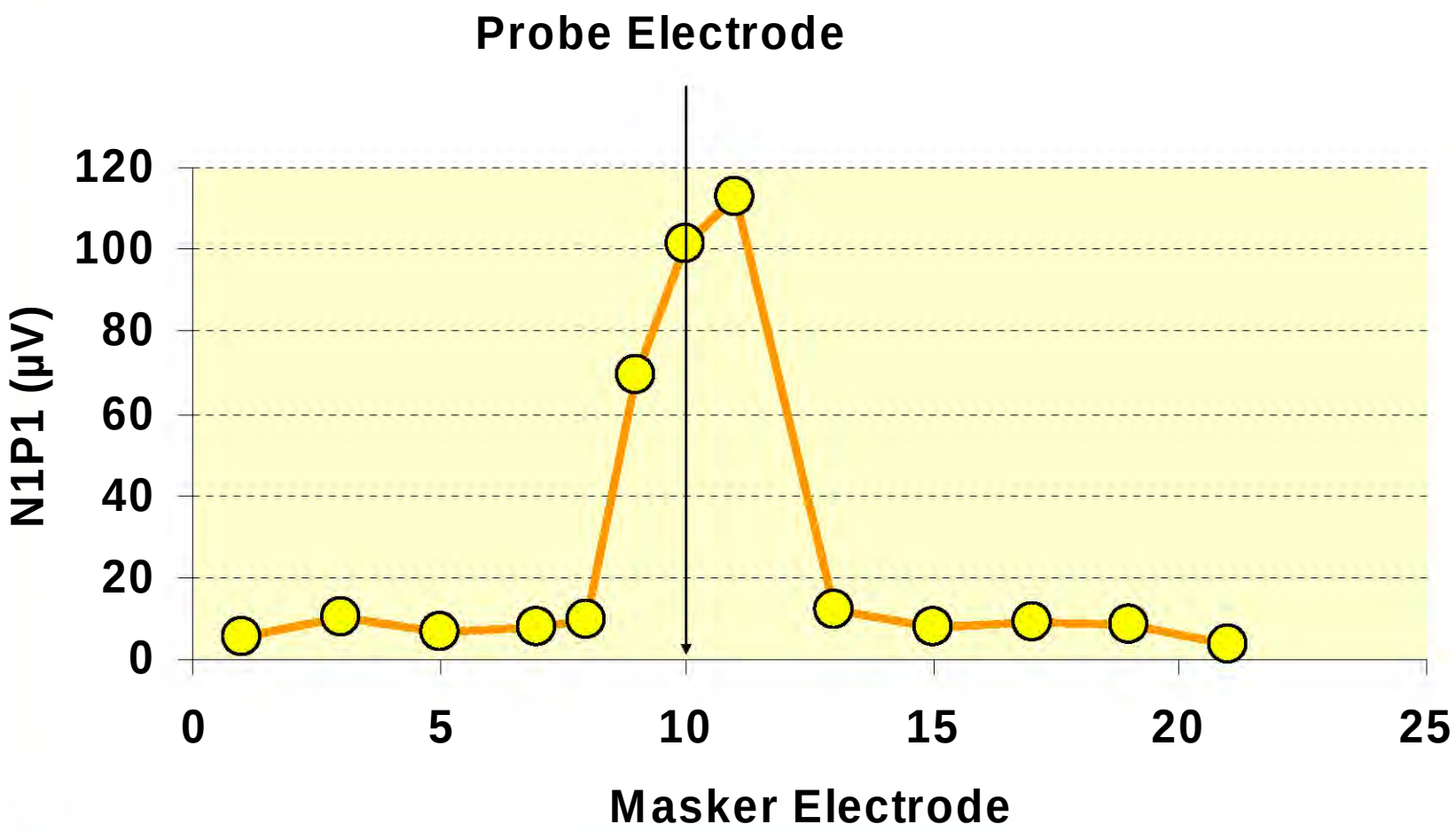
Rate Adaptation (n=7)



Recovery Functions



Spread of Excitation



Conclusions (RP8 – NRT)

- The enhanced signal-to-noise ratio combined with the new artifact cancellation option allow good quality recordings with only a limited number of averages.
- These results suggest more reliable, faster and easier NRT recordings in the next generation of Nucleus cochlear implant systems.