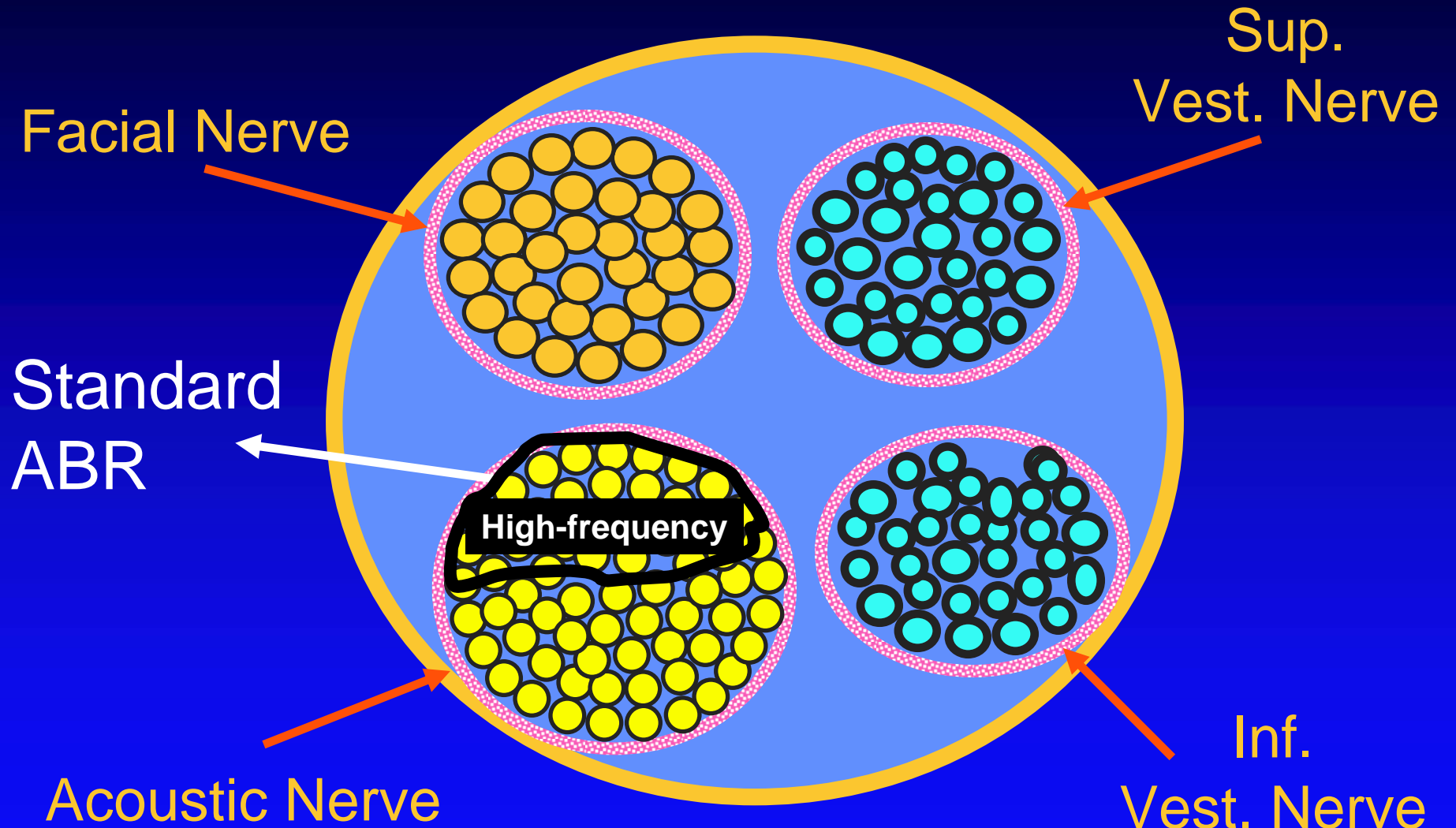


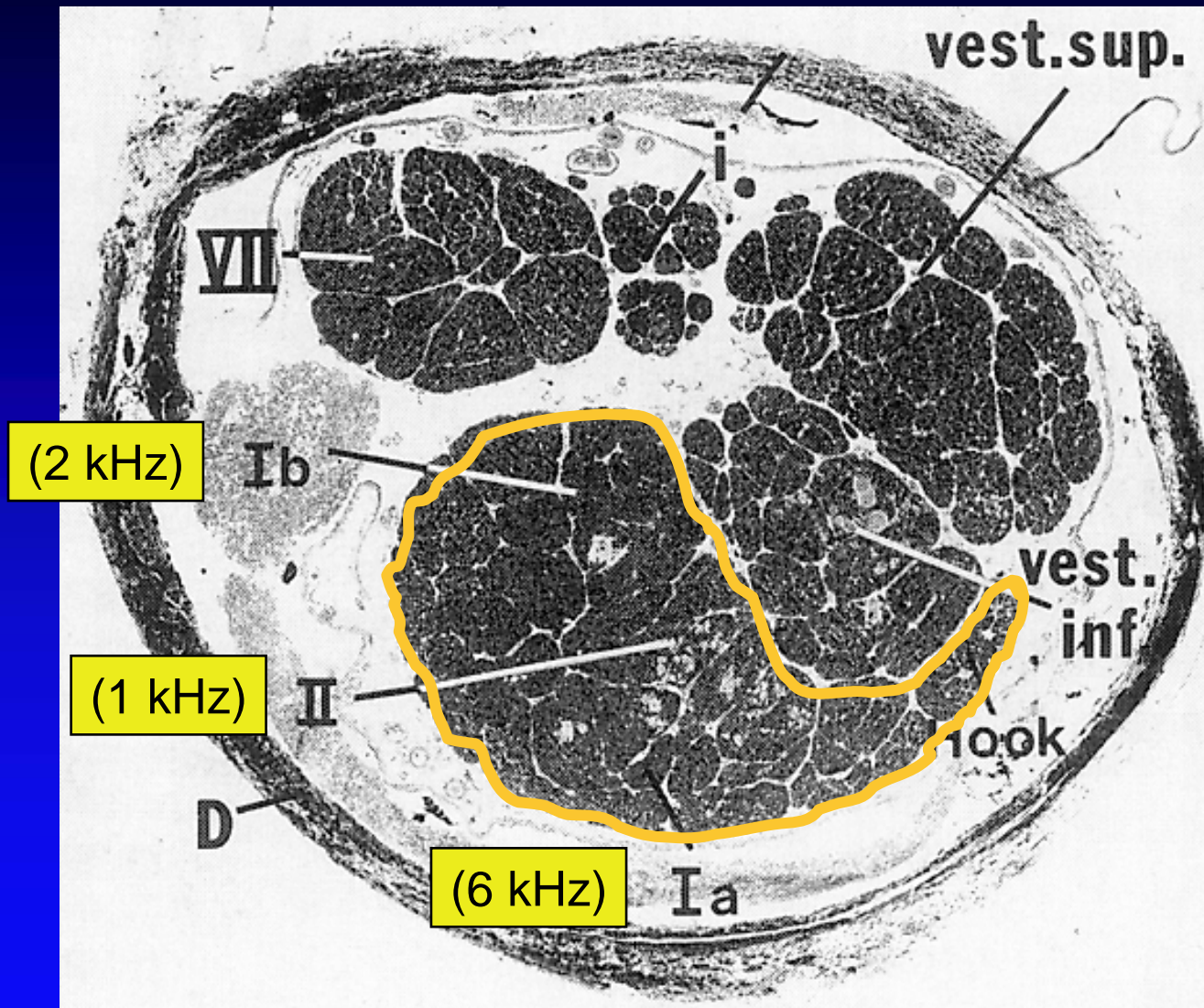
# A Brief Introduction to Stacked ABR and Cochlear Hydrops Analysis Masking Procedure (CHAMP)

Prepared for Bio-logic Systems Corp. by  
Manuel Don, Ph.D. / Betty Kwong, M.S.  
Electrophysiology Department  
House Ear Institute, Los Angeles, CA

# Normal Internal Auditory Canal (IAC)

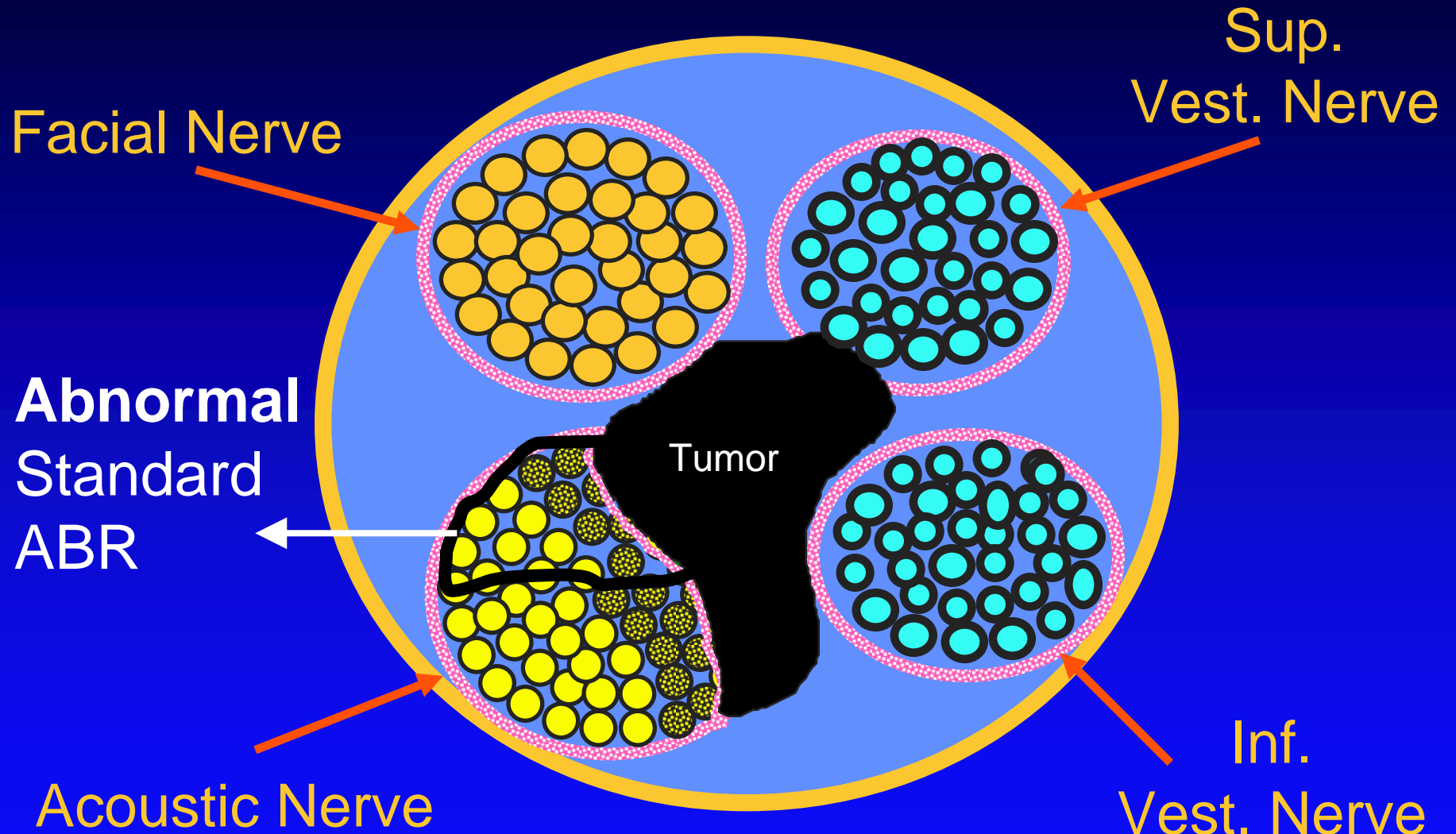


# Cross Section: Human Auditory Meatus

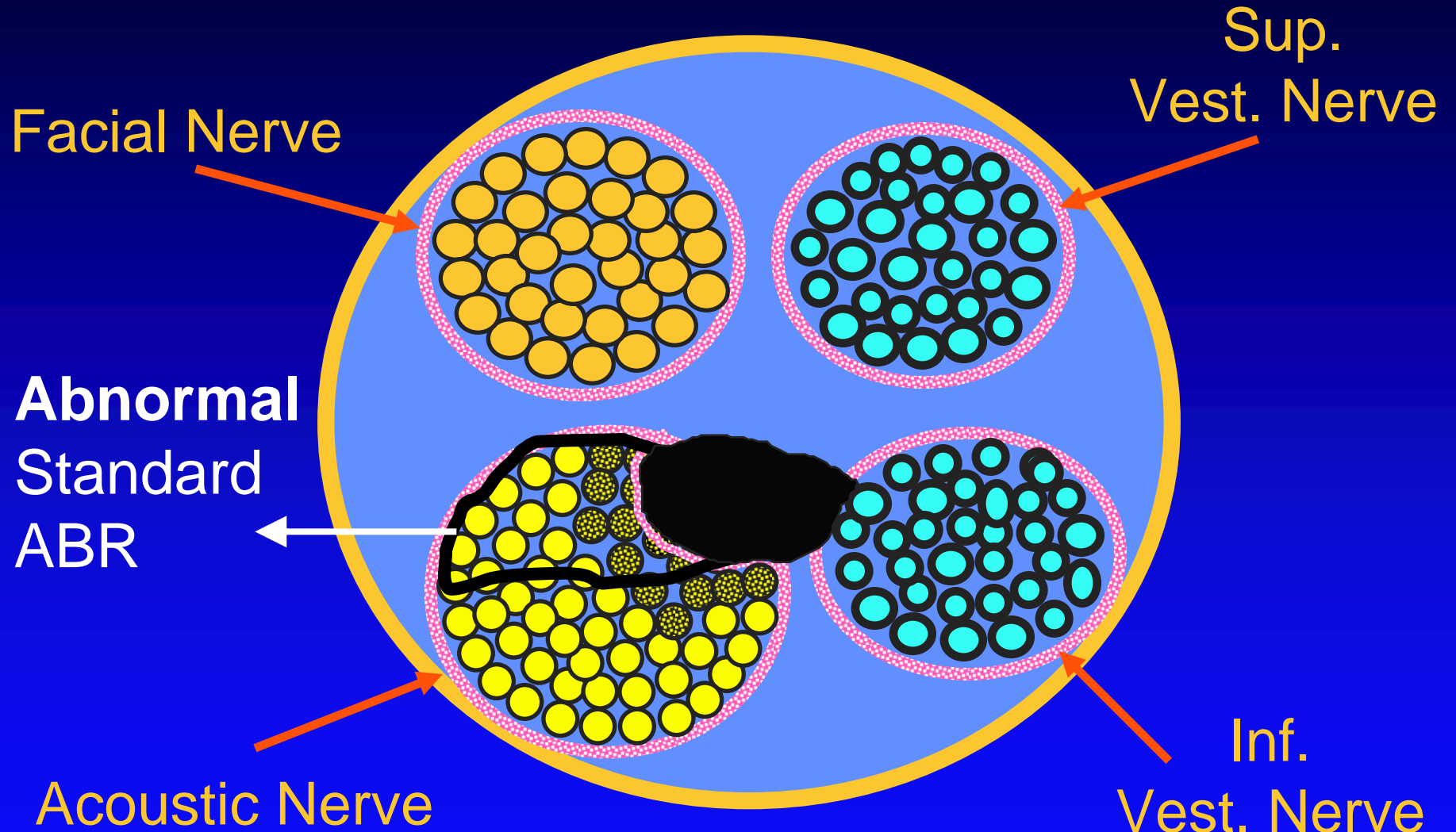


Spoendlin and Schrott (1989)

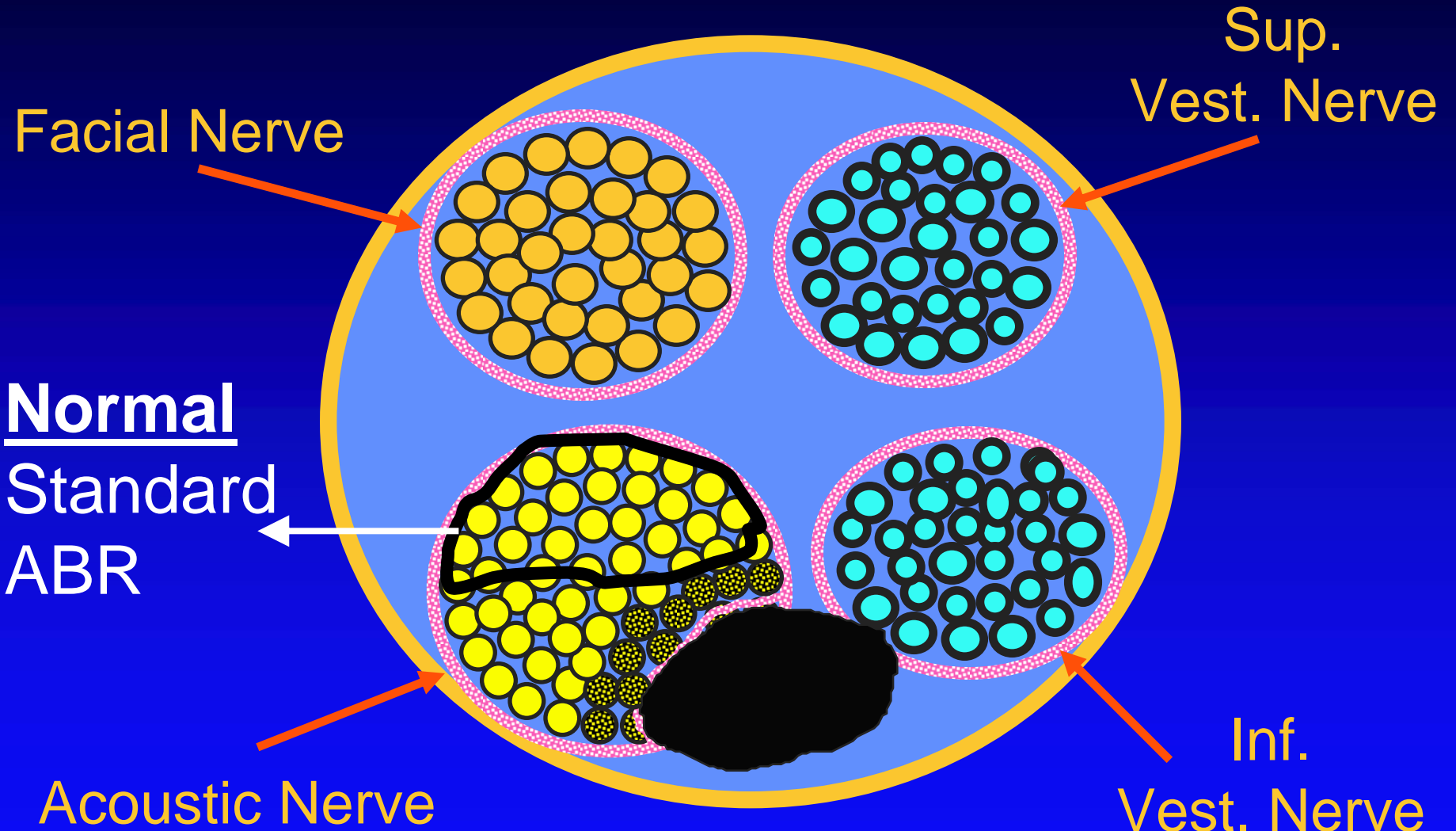
# Medium or Large Tumor in IAC



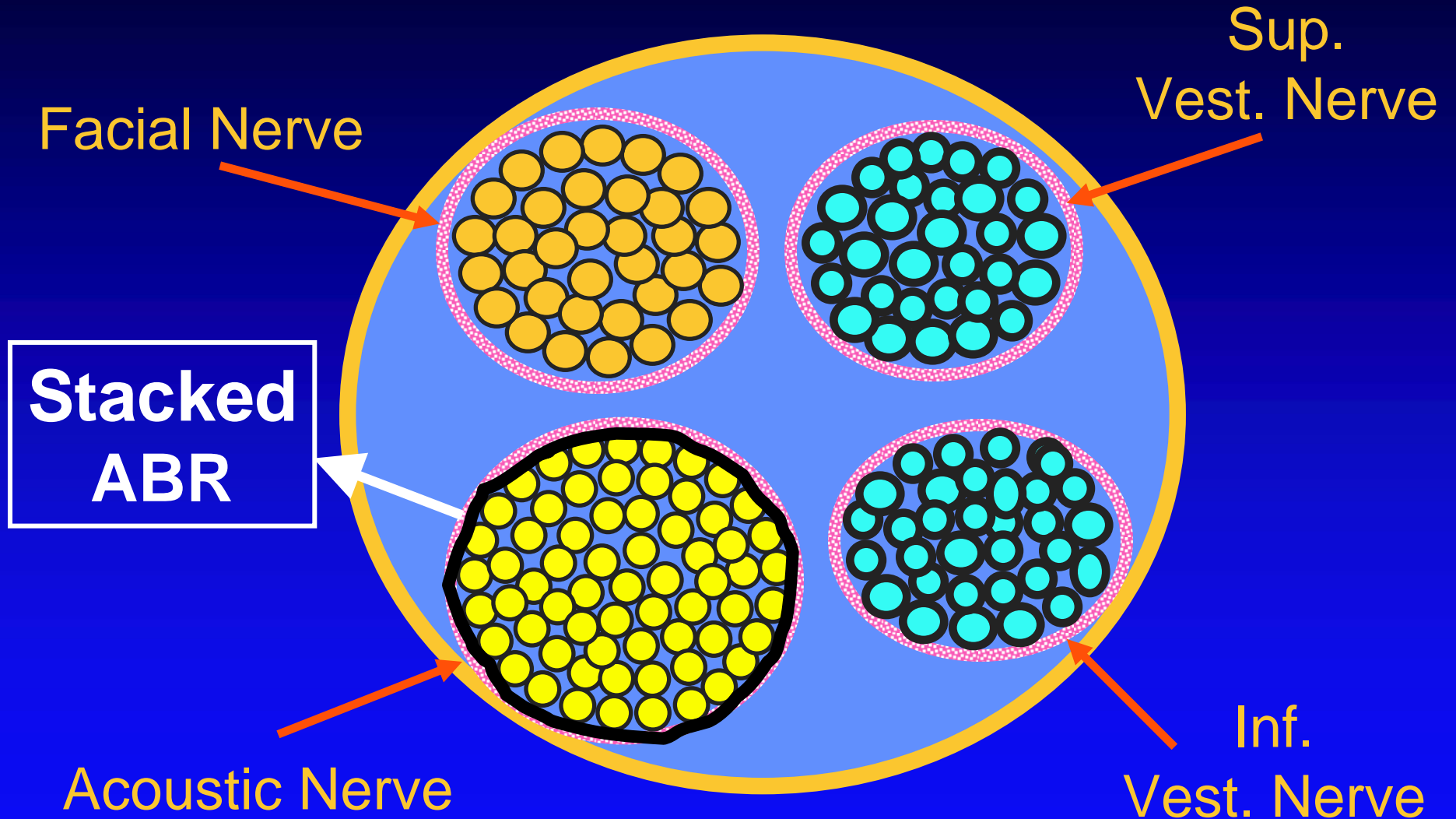
# Small Tumor in IAC



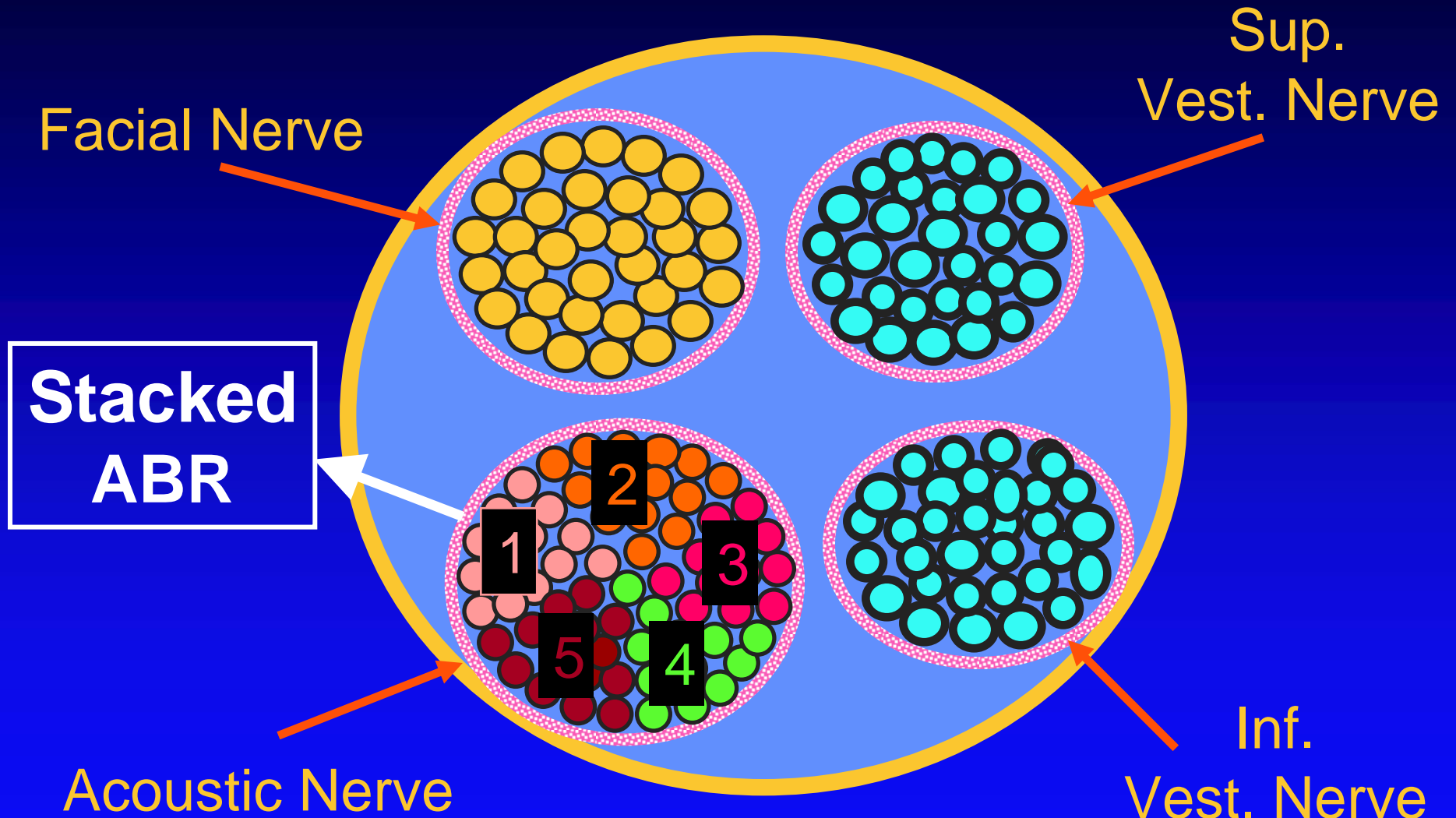
# Small Tumor in IAC



# Normal IAC



# Normal IAC



**Diagnostic Test:** If you add the activity from each of the five areas, is the amplitude normal?

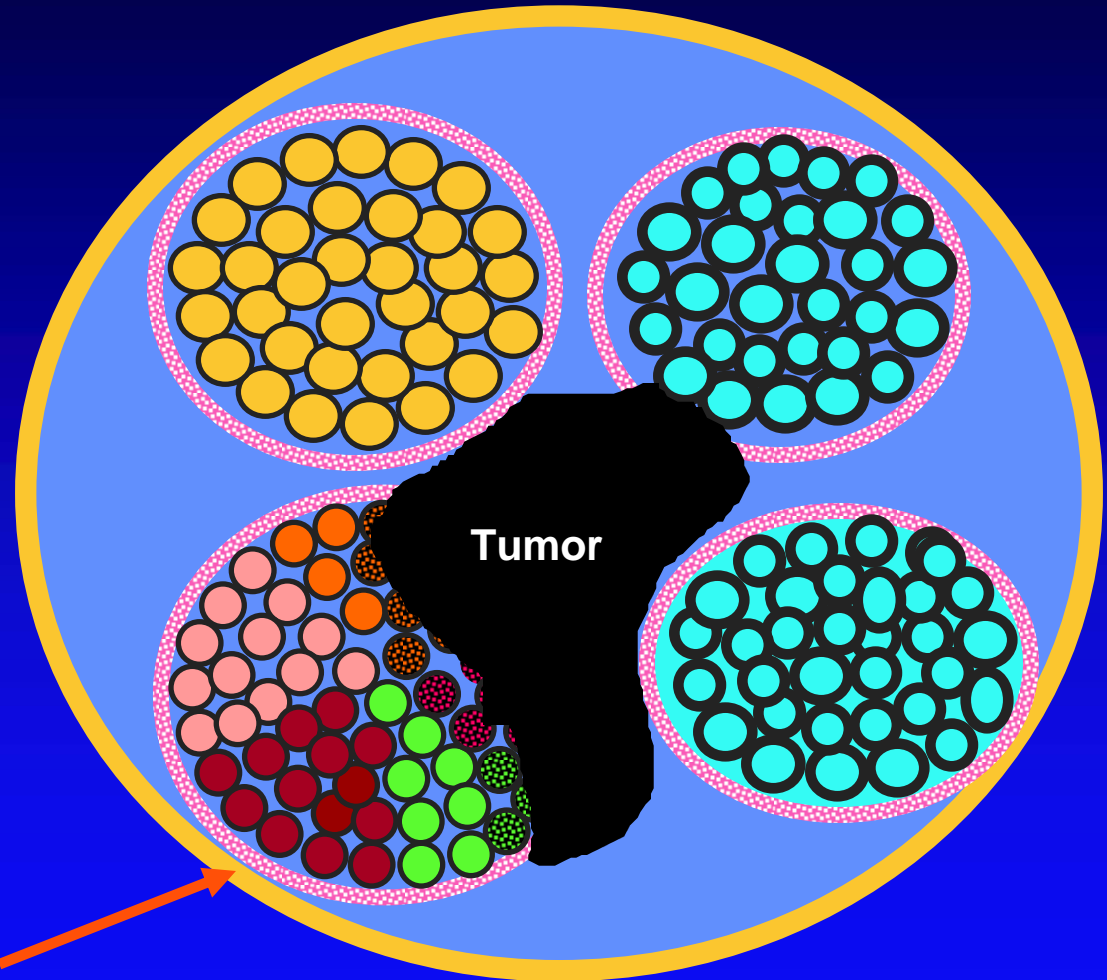
Activity from area 1  
+  
Activity from area 2  
+  
Activity from area 3  
+  
Activity from area 4  
+  
Activity from area 5



Normal Amplitude

# Medium or Large Tumor in IAC

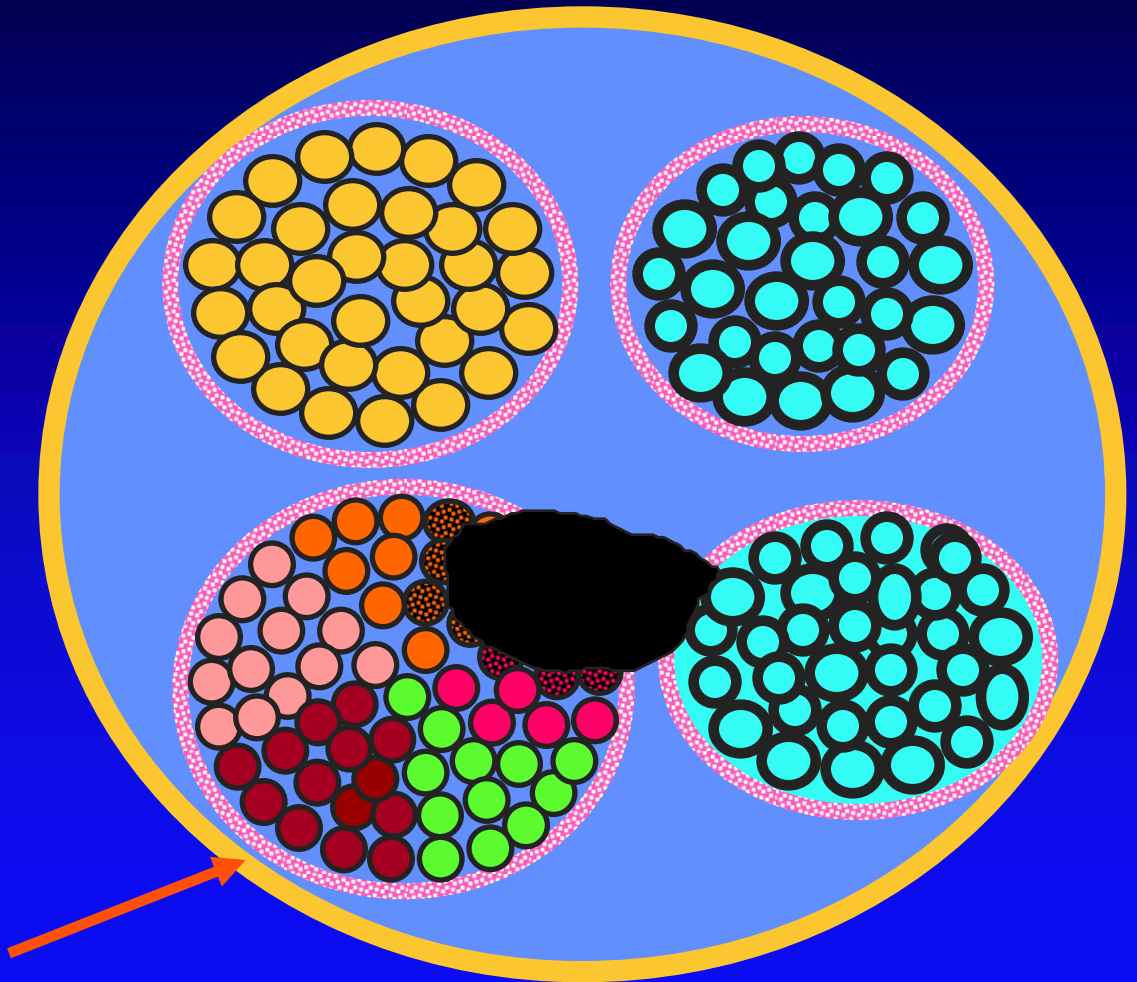
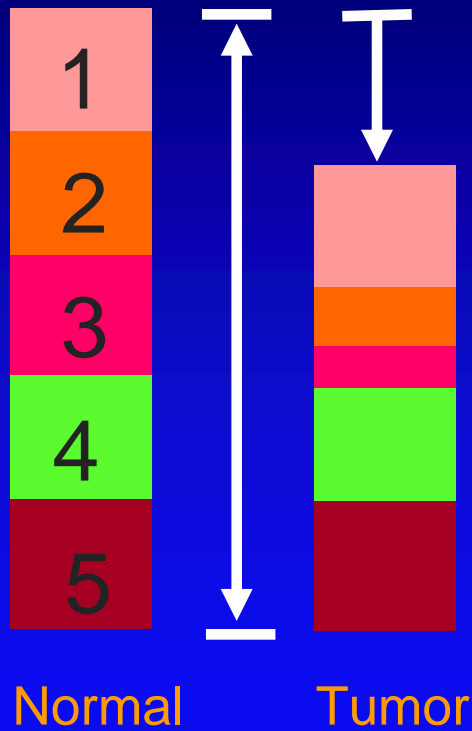
Abnormal  
Stacked ABR



Acoustic Nerve

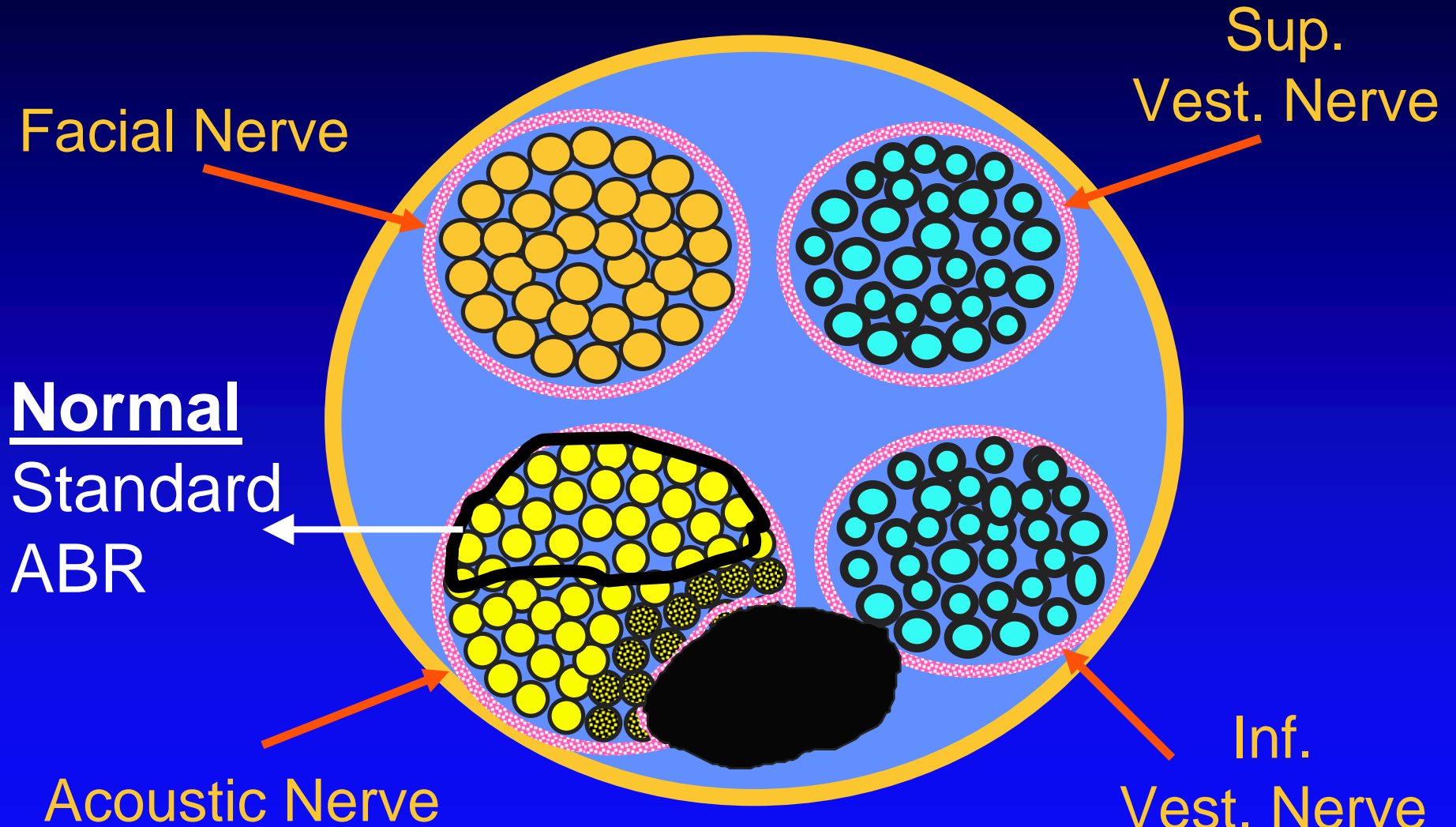
# Small Tumor in IAC

Abnormal  
Stacked ABR



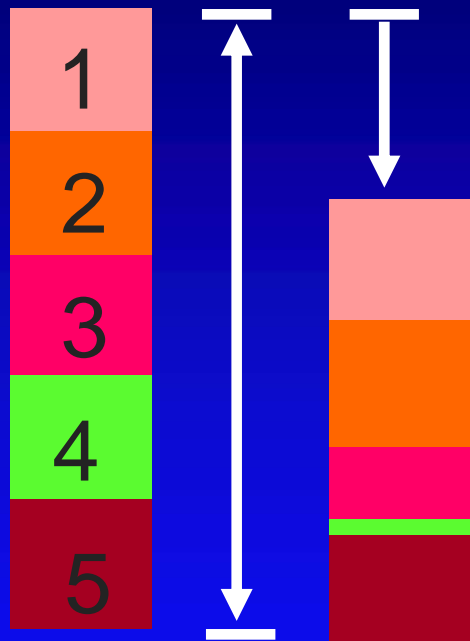
Acoustic Nerve

# Small Tumor in IAC Missed by Standard ABR



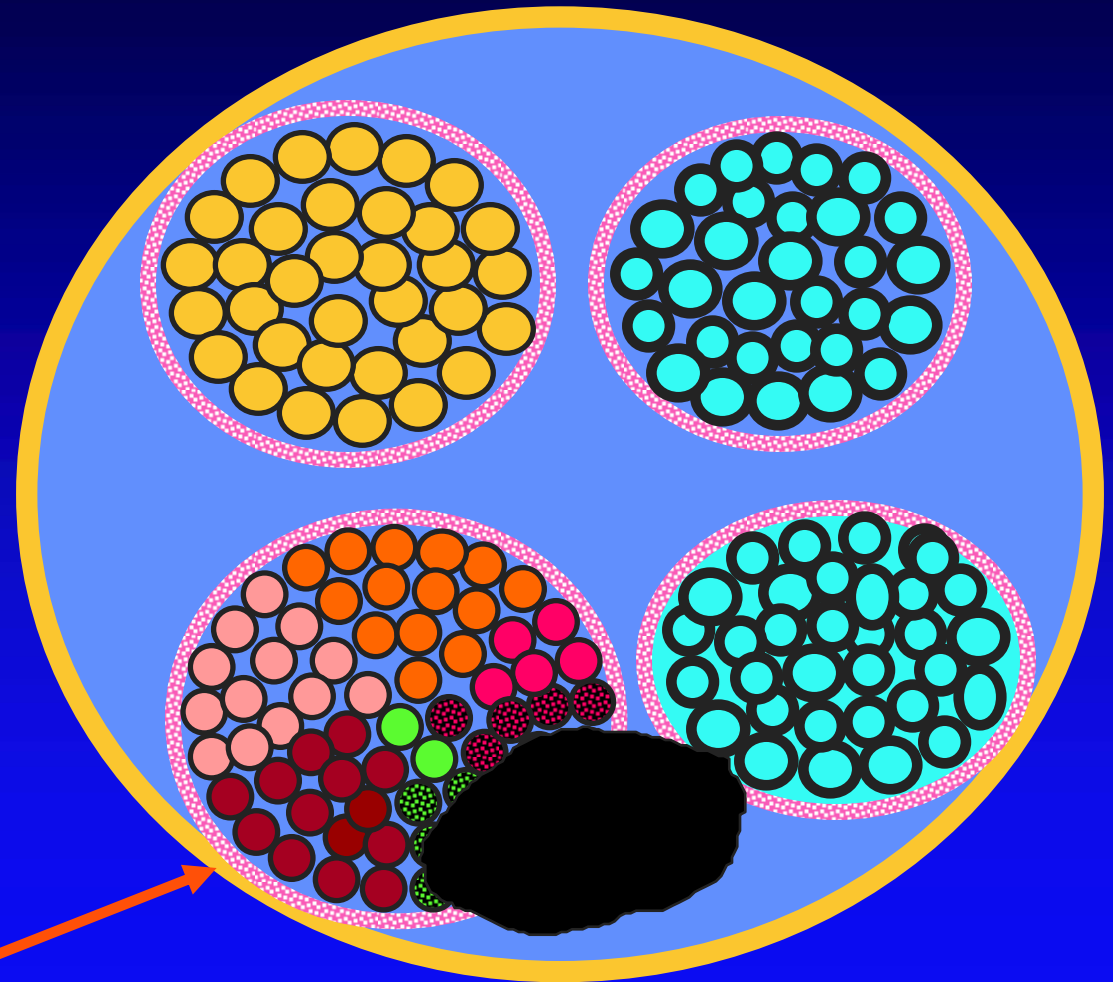
# Small Tumor in IAC

Abnormal  
Stacked ABR



Normal

Tumor



Acoustic Nerve

# Stacked ABR Measure

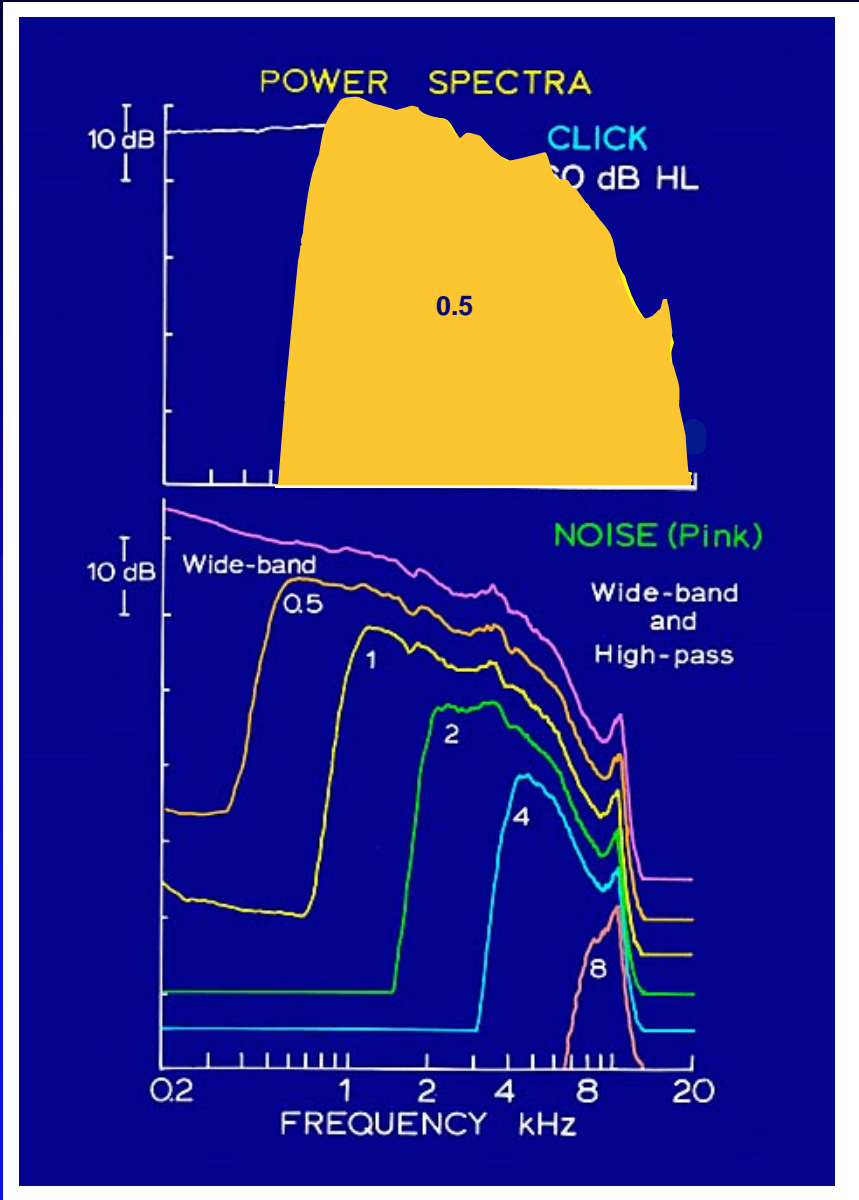
## Requirements

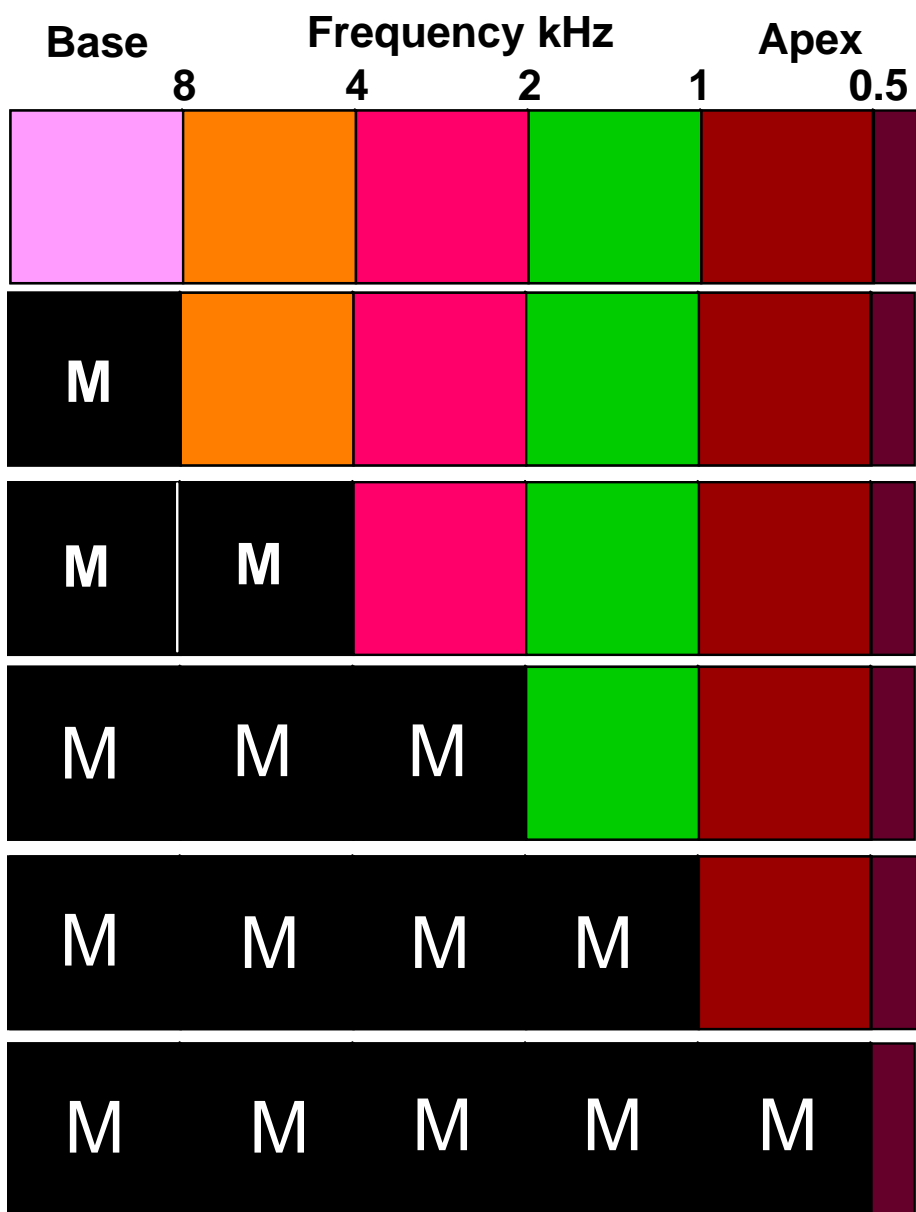
## Proposed Methods

- |   |    |                                |
|---|----|--------------------------------|
| 1. An auditory signal that stimulates essentially <b>all frequency regions</b> of the cochlea   | => | Wide-band Click                |
| 2. A method for <b>separating the responses</b> from different frequency regions of the cochlea | => | The Derived-band ABR Technique |
| 3. A procedure for <b>summing the responses</b> to approximate total neural activity            | => | The Stacking Technique         |

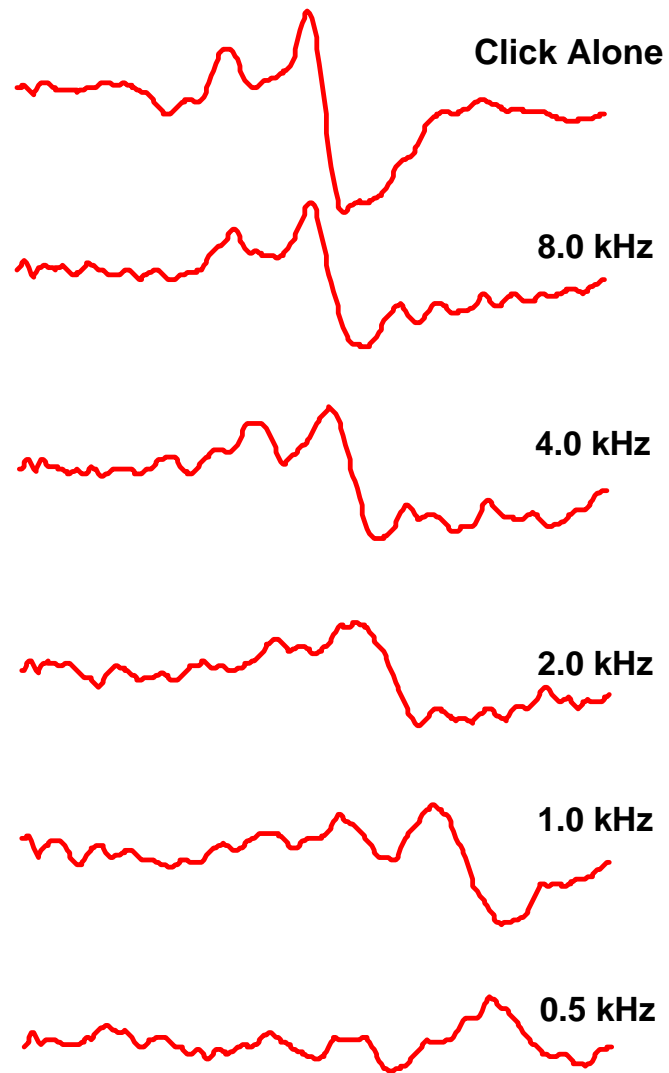
Click

High-pass  
Masking Noise  
(8.0, 4.0, 2.0, 1.0, and 0.5 kHz)



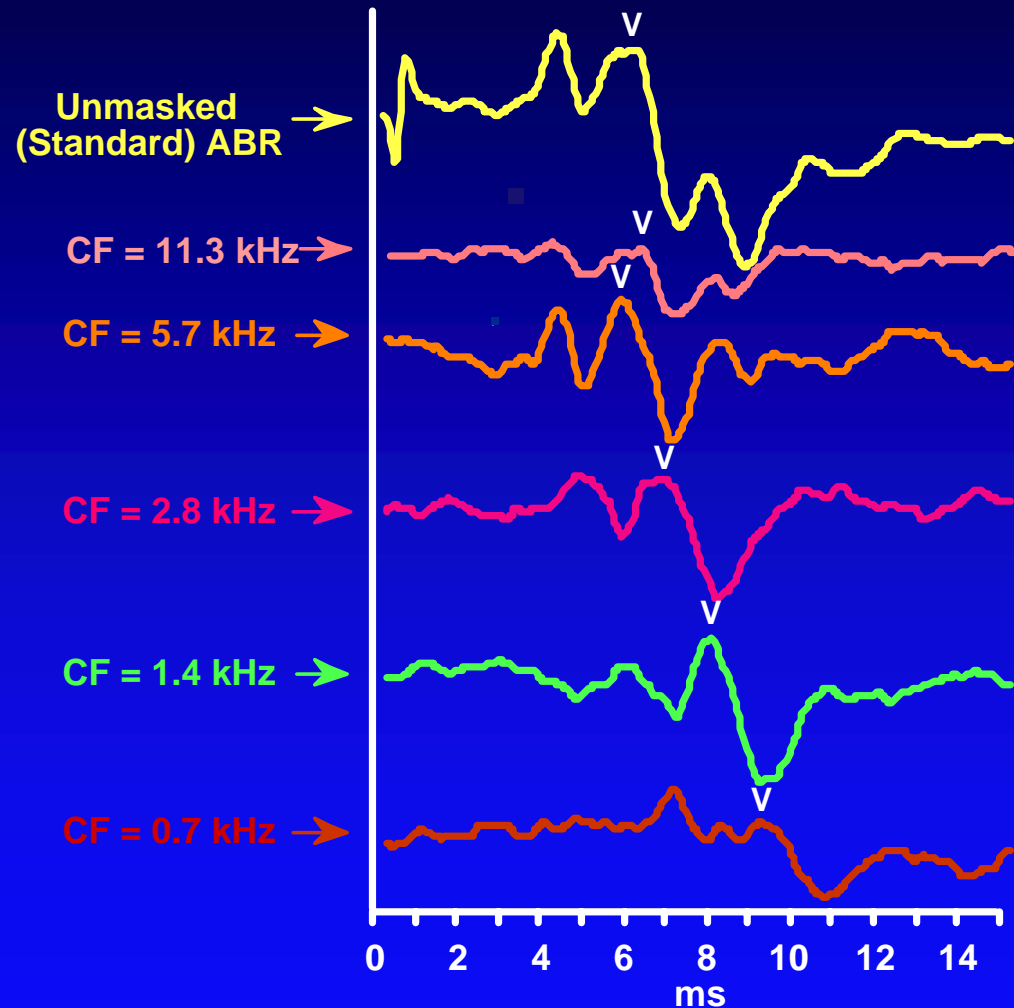


### Click Alone and High Pass Noise Responses



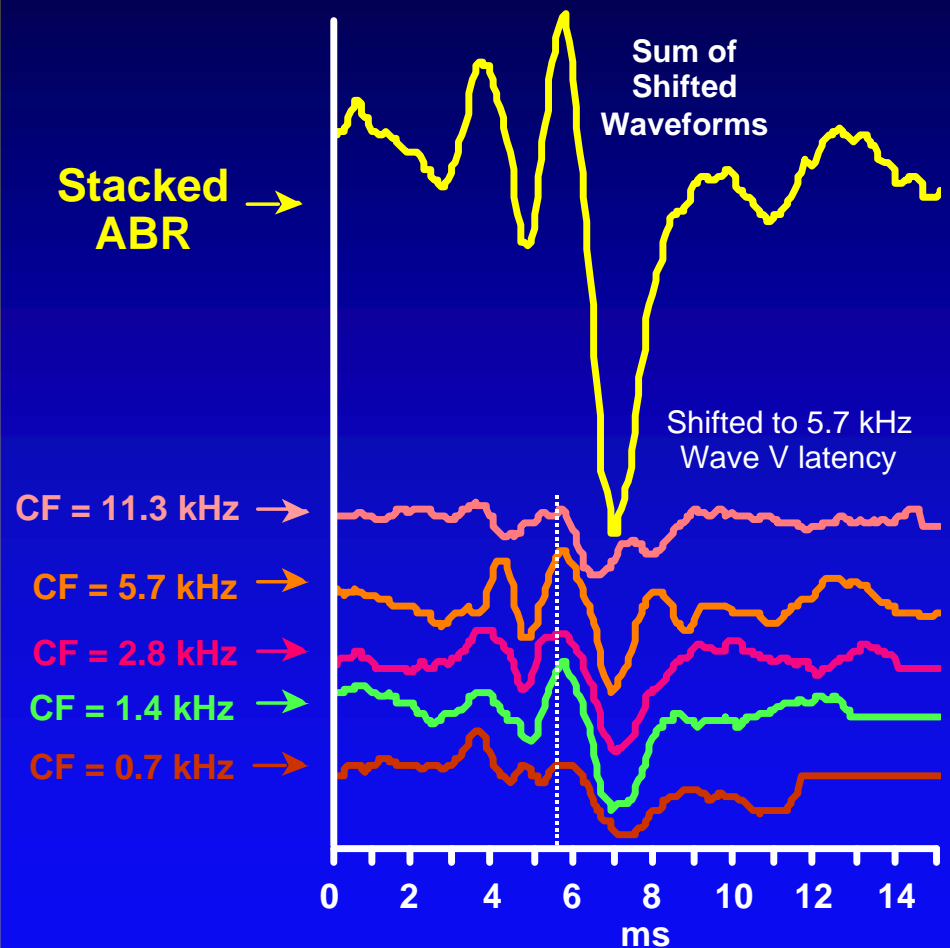
# The Derived-band ABR Technique

The derived-band technique uses subtraction of the click alone response and the five different high pass responses to obtain five derived-band ABRs that reflect the neural contributions from five different octave-wide frequency regions of the cochlea.

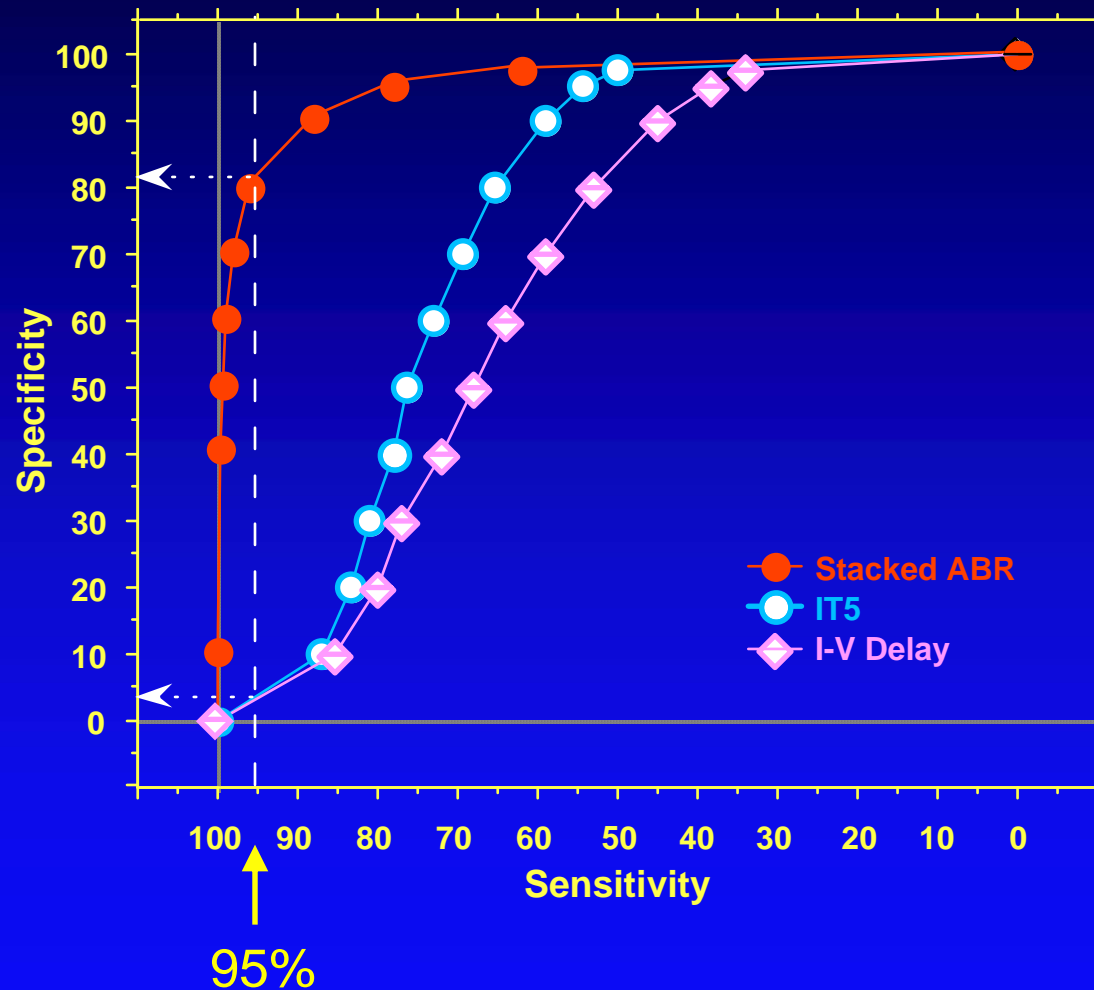


# The Stacking Technique

- The **Stacked ABR** is formed by first temporally **aligning wave V** of the derived-band ABRs, then **summing the responses**.
- Aligning the derived-band ABRs eliminates phase cancellation of lower frequency activity. Thus, the Stacked ABR amplitude reflects activity from **all** frequency regions of the cochlea, not just the high frequencies.
- Reduction of **any** neural activity due to a tumor, even a small tumor, will result in a reduction of the Stacked ABR amplitude.



# Standard vs Stacked ABR Measures



## For 95% sensitivity

(that is, for correct identification of 95 out of every 100 small tumors):

The **IT5** and **I-V Delay** measures have less than 5% specificity

(that is, the IT5 and I-V Delay correctly identify less than 5 out of every 100 non-tumor patients),

**But the Stacked ABR has 83% specificity**

(that is, the Stacked ABR correctly identifies 83 out of every 100 non-tumor patients)!

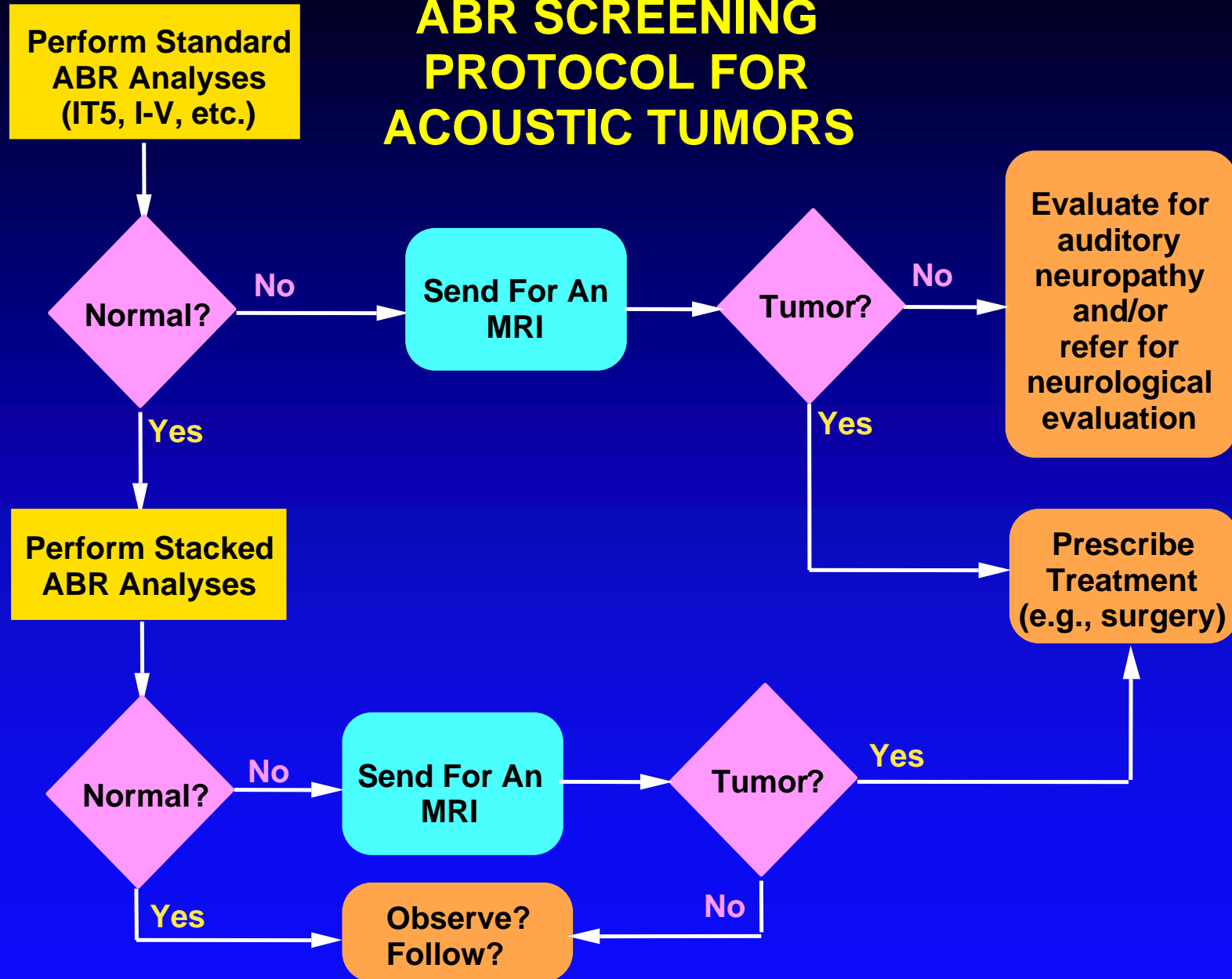
# CONCLUSION

**The Stacked ABR appears to have better sensitivity and specificity than the standard ABR for small ( $\leq 1$  cm) tumors.**

In other words, the Stacked ABR is better at :

1. detecting small tumors, and
2. decreasing the number of misdiagnosed non-tumor patients (i.e., decreasing the number of false-positives referred for MRI).

# ABR SCREENING PROTOCOL FOR ACOUSTIC TUMORS



# Breaking News: Meniere's Disease

- Symptoms of early Meniere's disease and small acoustic tumors are similar.
- There's a pattern in the high pass responses of patients with Meniere's disease that may be used to help with the differential diagnosis.

Endolymphatic Hydrops

```
graph TD; A[Endolymphatic Hydrops] --> B[Alters Basilar Membrane Parameters (e.g., stiffness, fluid column height, etc.)]; B --> C[Changes how cochlea processes auditory stimuli];
```

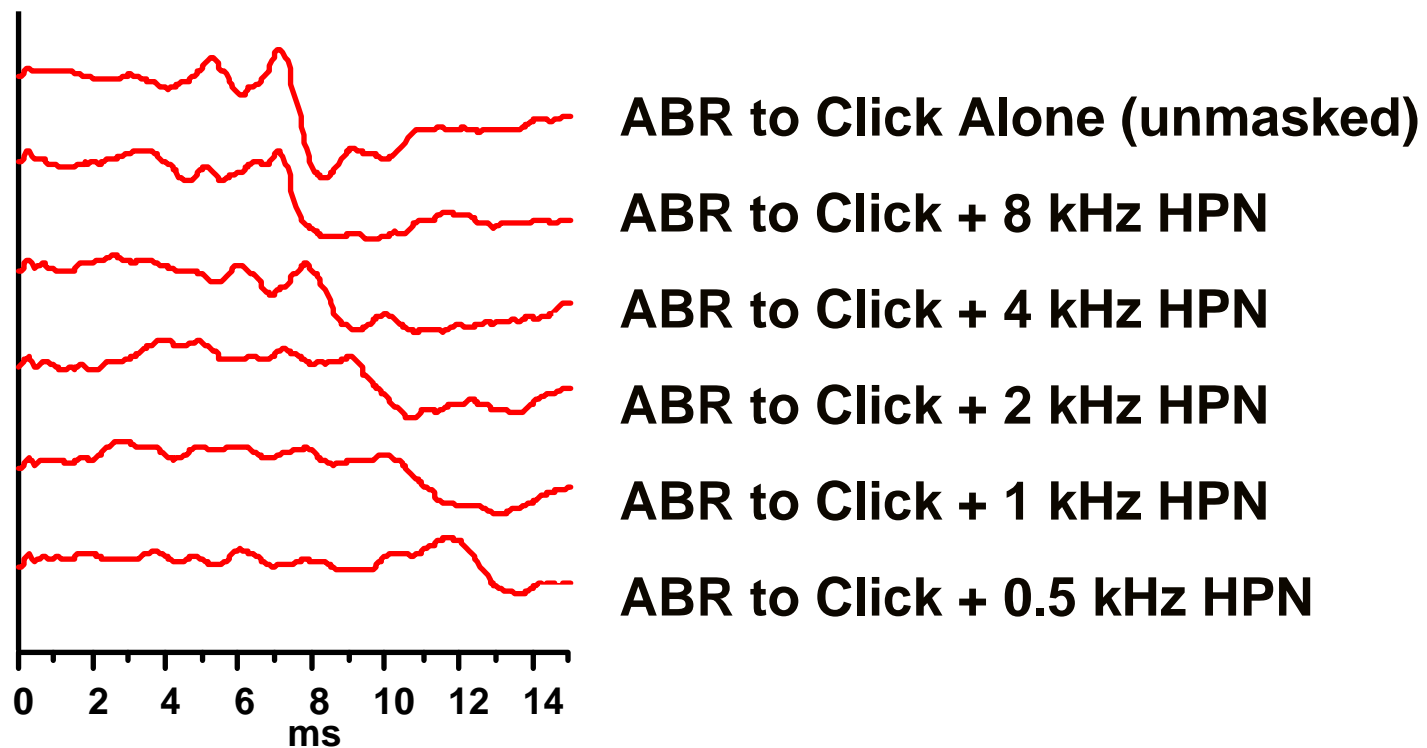
Alters Basilar Membrane Parameters  
(e.g., stiffness, fluid column height, etc.)

Changes how cochlea processes  
auditory stimuli

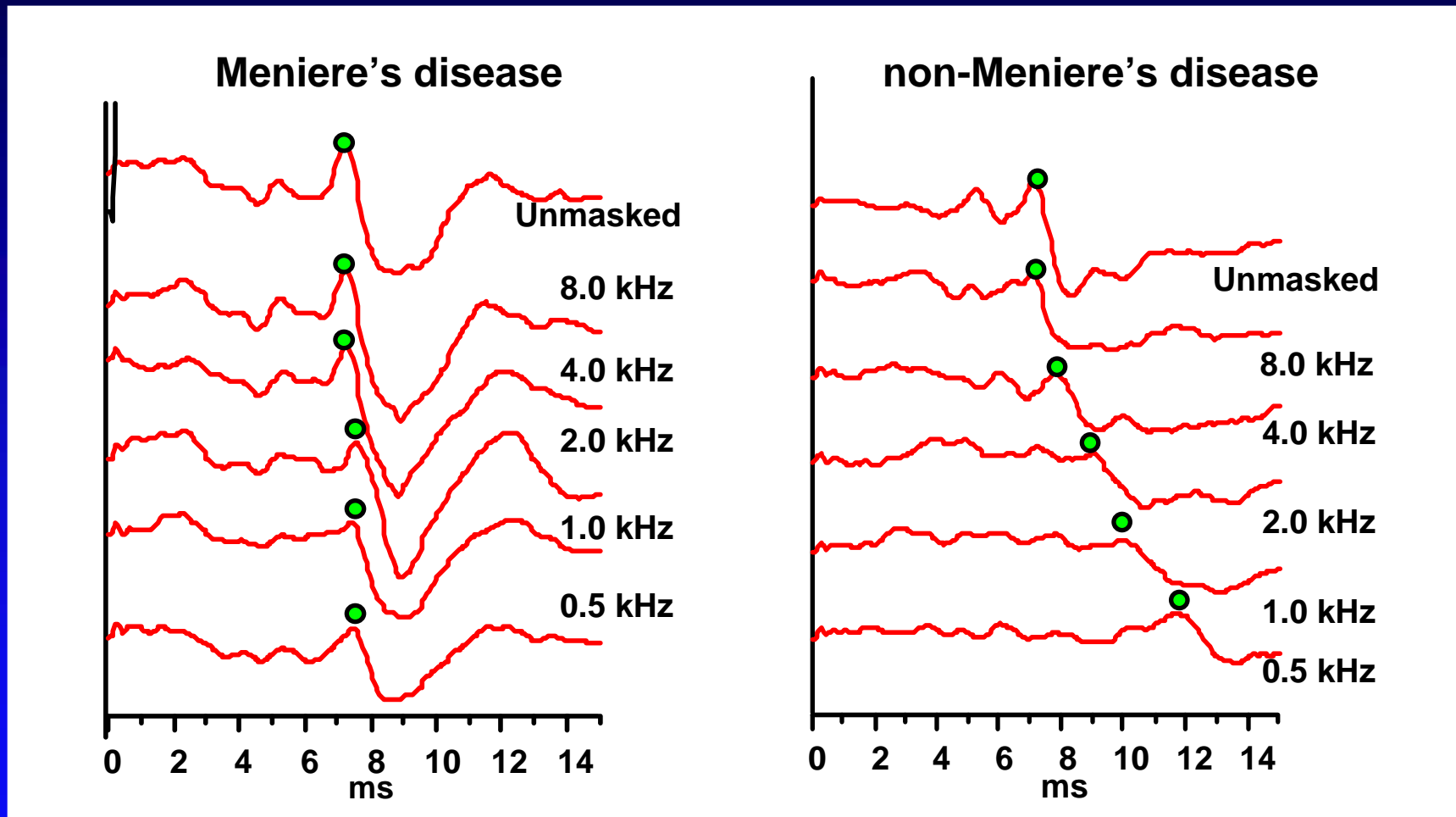
## In Meniere's disease, we think that:

- Cochlear hydrops alters the response properties of the basilar membrane.
- Low frequency masking noise is less effective for masking activity in higher frequency regions.
- Thus, we observe undermasking in the high pass responses.

## Click Alone (Unmasked) and High Pass Noise (HPN) Responses

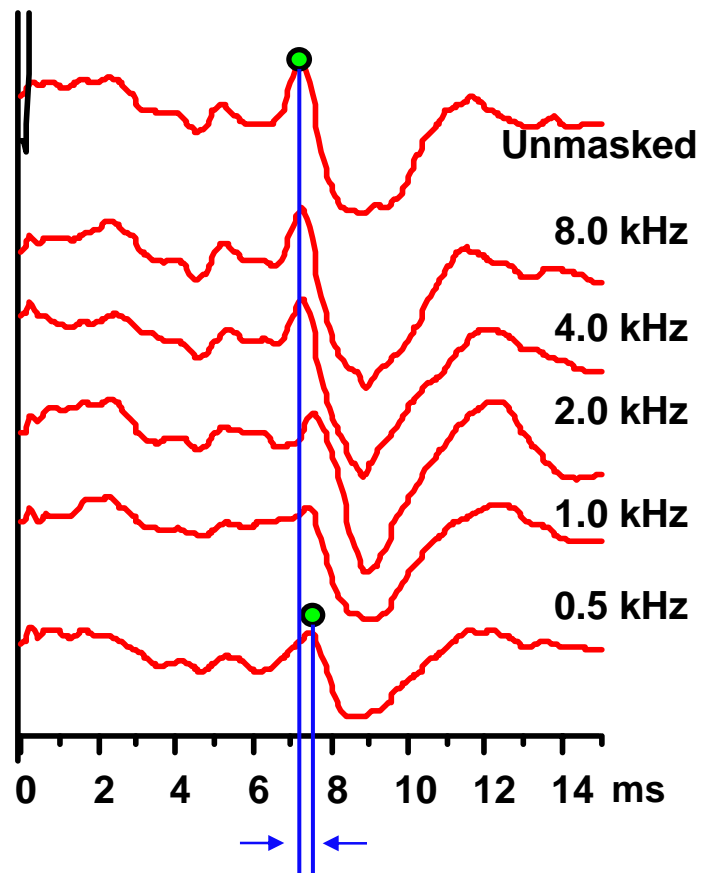


# Undermasking in Meniere's Disease

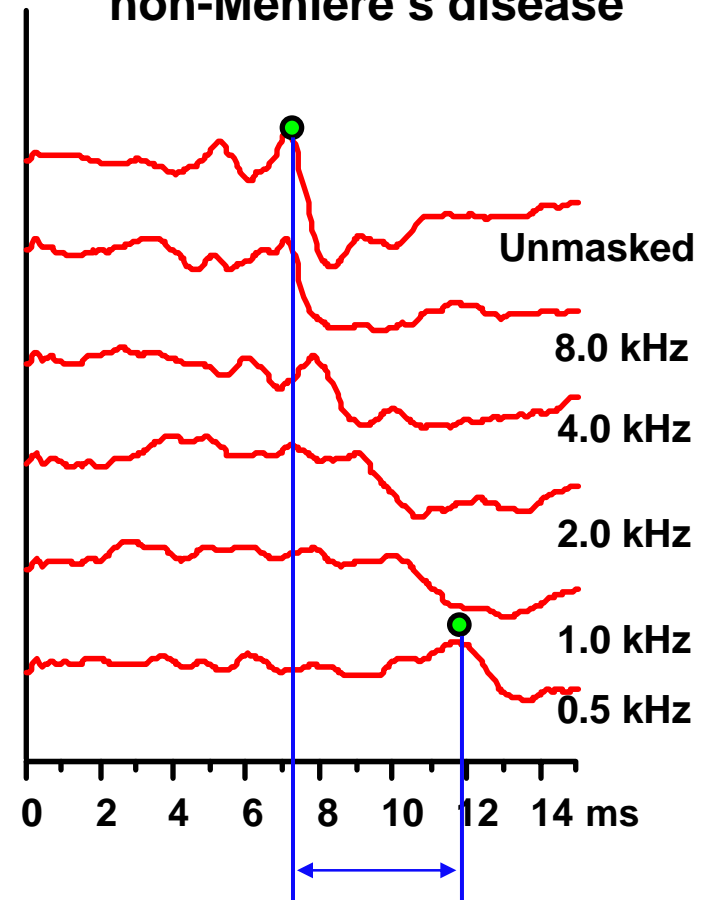


# Wave V Latency Delay (500 Hz HP – Click Alone)

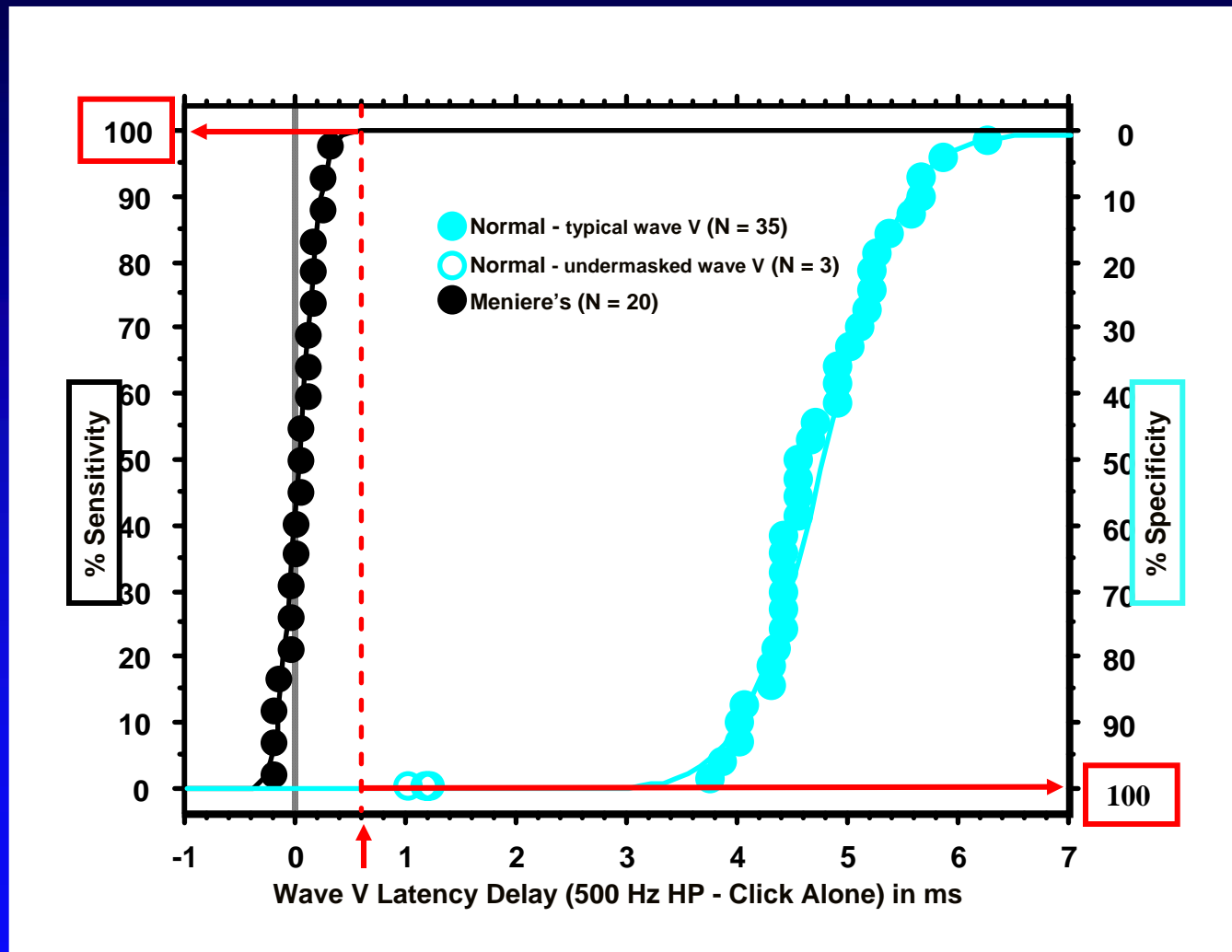
Meniere's disease



non-Meniere's disease



# Wave V Latency Delay (500 Hz HP – Click Alone)



## Current Status

- In addition to the wave V latency delay, we are investigating other measures of this undermasking phenomenon.
- We are also analyzing data from non-Meniere's disease subjects with hearing loss and patients diagnosed with cochlear hydrops, not Meniere's disease.
- Preliminary results show very good separation of Meniere's disease/cochlear hydrops patients and non-Meniere's disease subjects.

## IMPORTANT!

- Do not confuse the Stacked ABR method with this method for evaluating Meniere's disease.
- The Stacked ABR is for small tumor detection and is not used for Meniere's disease assessment.
- Stacked ABR uses the sum of the aligned derived-band (subtracted) ABRs while the Meniere's test uses only the high-passed noise masked responses to clicks.

# Staff Acknowledgements

## Department of Electrophysiology

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## Department of Histopathology

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## Support

NIH/NIDCD 1R43 DC04141 Raviv (PI)

NIH/NIDCD 2R44 DC04141 Raviv (PI)

NIH/NIDCD R01 DC03592 Don (PI)

# References

**Don M, Masuda A, Nelson RA, and Brackmann DE (1997).** Successful Detection of Small Acoustic Tumors Using the Stacked Derived Band ABR method. *Am J Otolaryngol.*; 18: 608-621.

**Don M and Kwong B (2002).** Auditory Brainstem Response: Differential Diagnosis. In: Katz J, Eds. *Handbook of Clinical Audiology*, Fifth Edition. Pennsylvania: Lippincott Williams & Wilkins Publishing; pp. 274-297.

**Don M (2002).** Auditory brainstem response testing in acoustic neuroma diagnosis. *Current Opinion in Otolaryngology & Head and Neck Surgery* 10:376-381.

**Don M, Kwong B, Tanaka C, Brackmann DE, Nelson RA (2005)** The Stacked ABR: A Sensitive and Specific Screening Tool for Detecting Small Acoustic Tumors (*Audiology & Neurotology* 10: 274-290)

**Don M, Kwong B, Tanaka C (2005)** A Diagnostic Test for Meniere's Disease and cochlear Hydrops: Impaired High-pass Noise Masking ABRs. (*Otology & Neurotology* 26: 711-722.)