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

Prepared for Bio-logic Systems Corp. by

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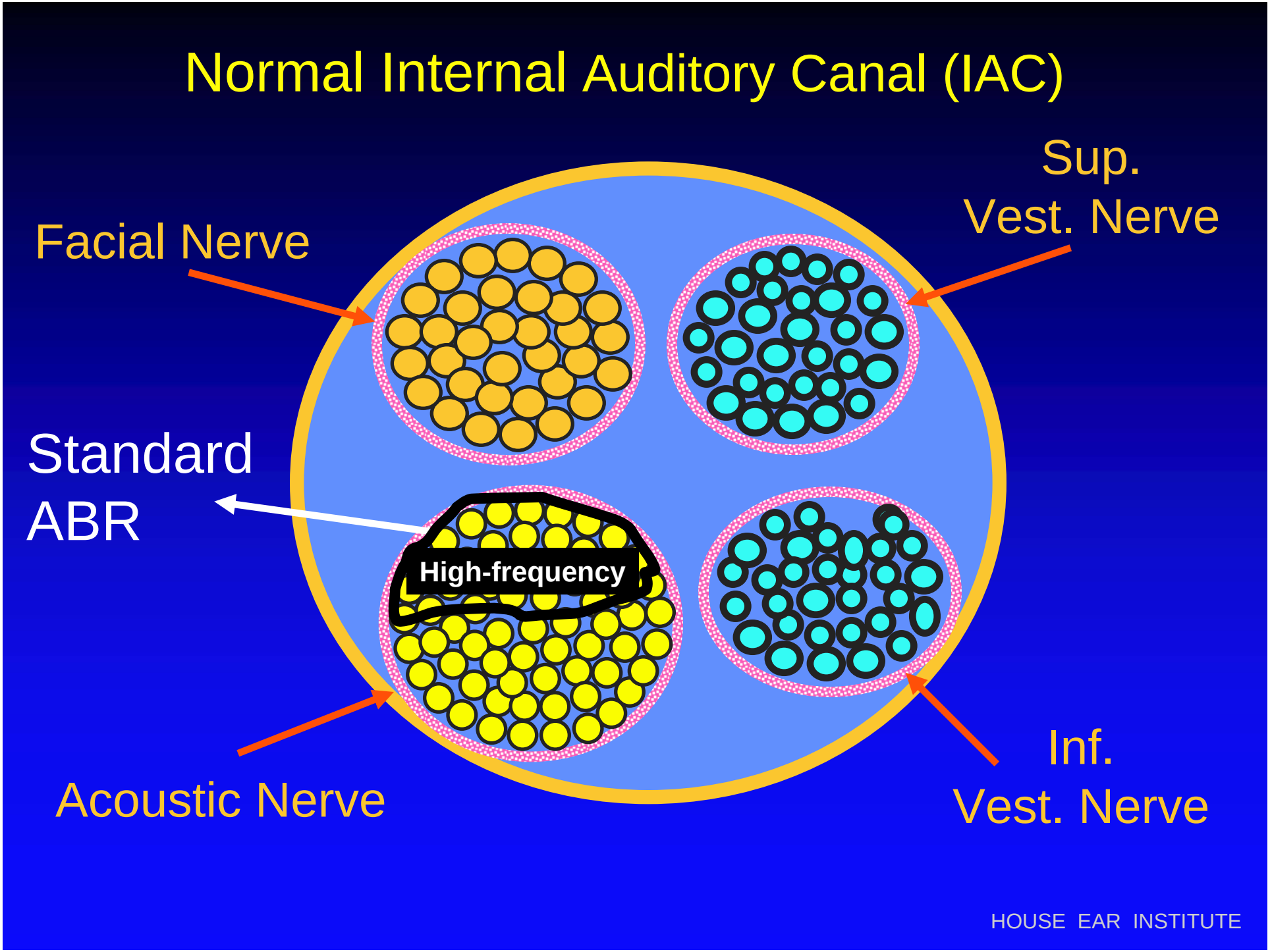
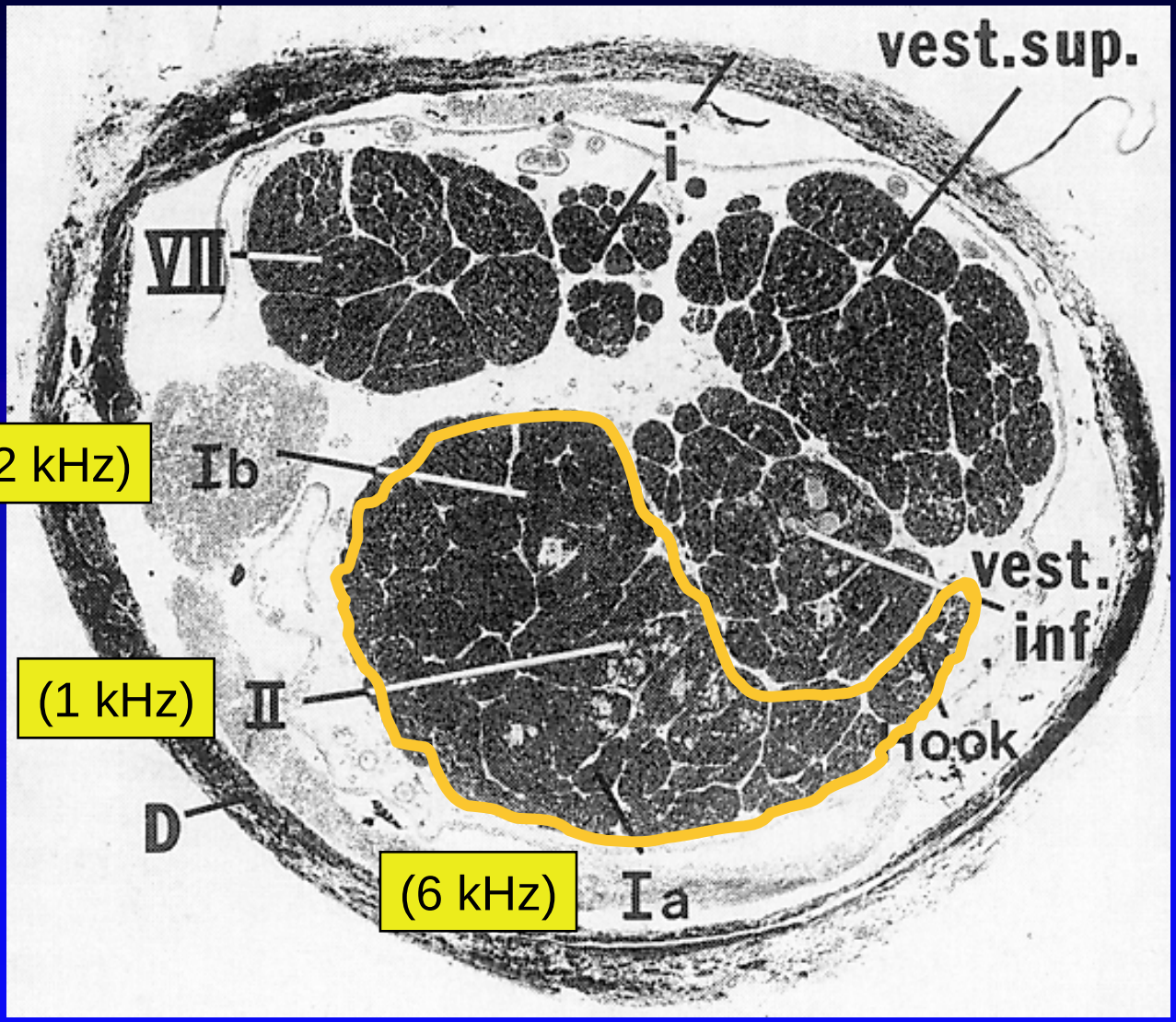
Normal Internal Auditory Canal (IAC)

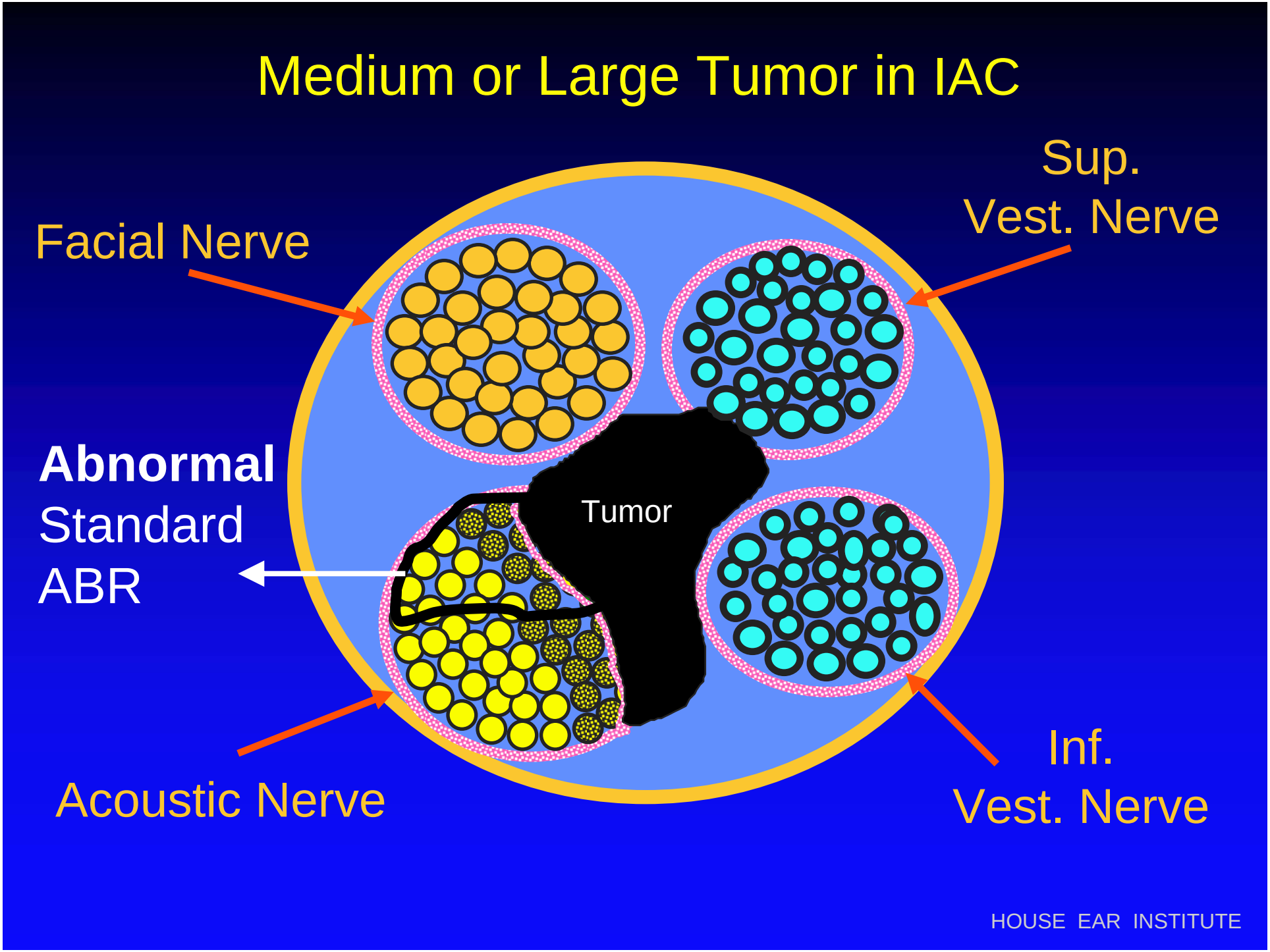


Cross Section: Human Auditory Meatus

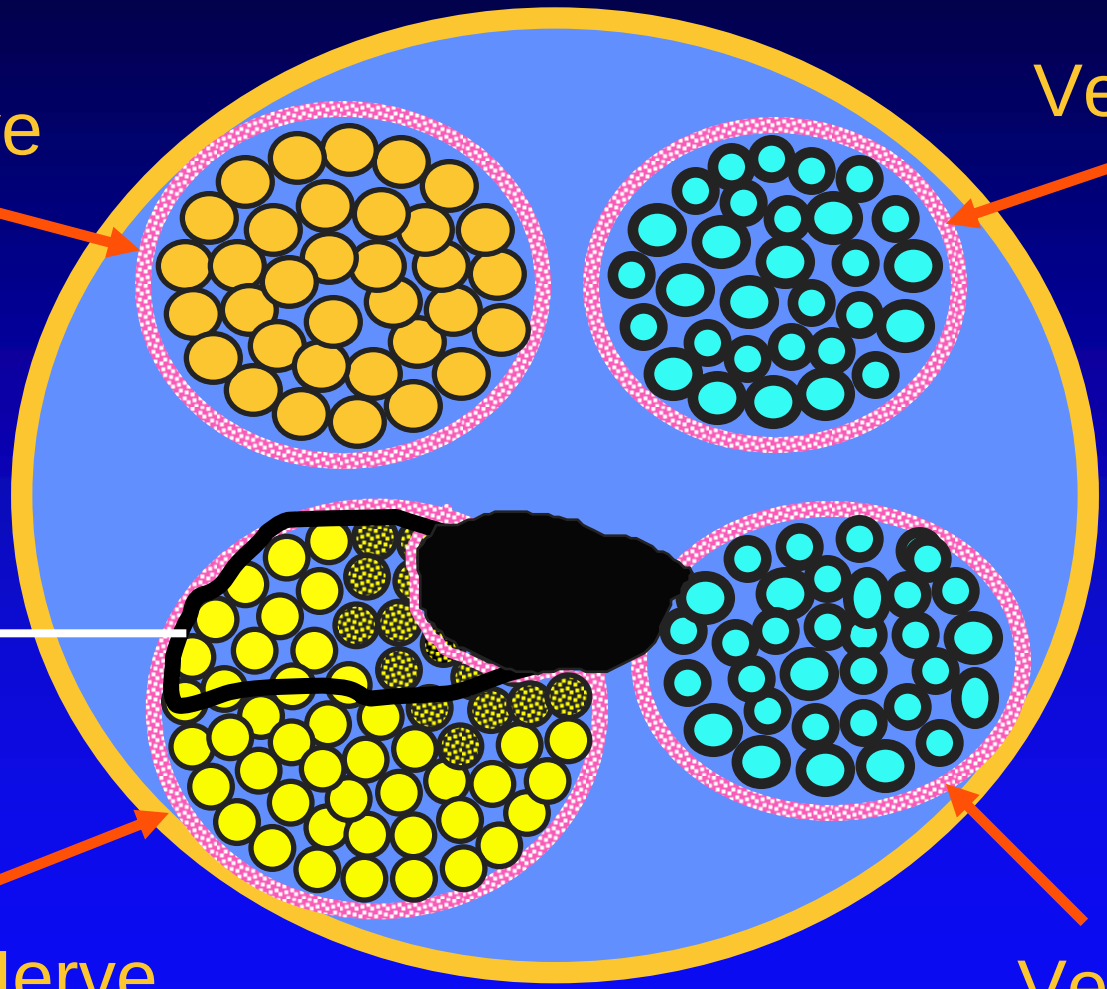


Spoendlin and Schrott (1989)

Medium or Large Tumor in IAC



Small Tumor in IAC



Facial Nerve

Sup.
Vest. Nerve

Abnormal
Standard
ABR

Acoustic Nerve

Inf.
Vest. Nerve

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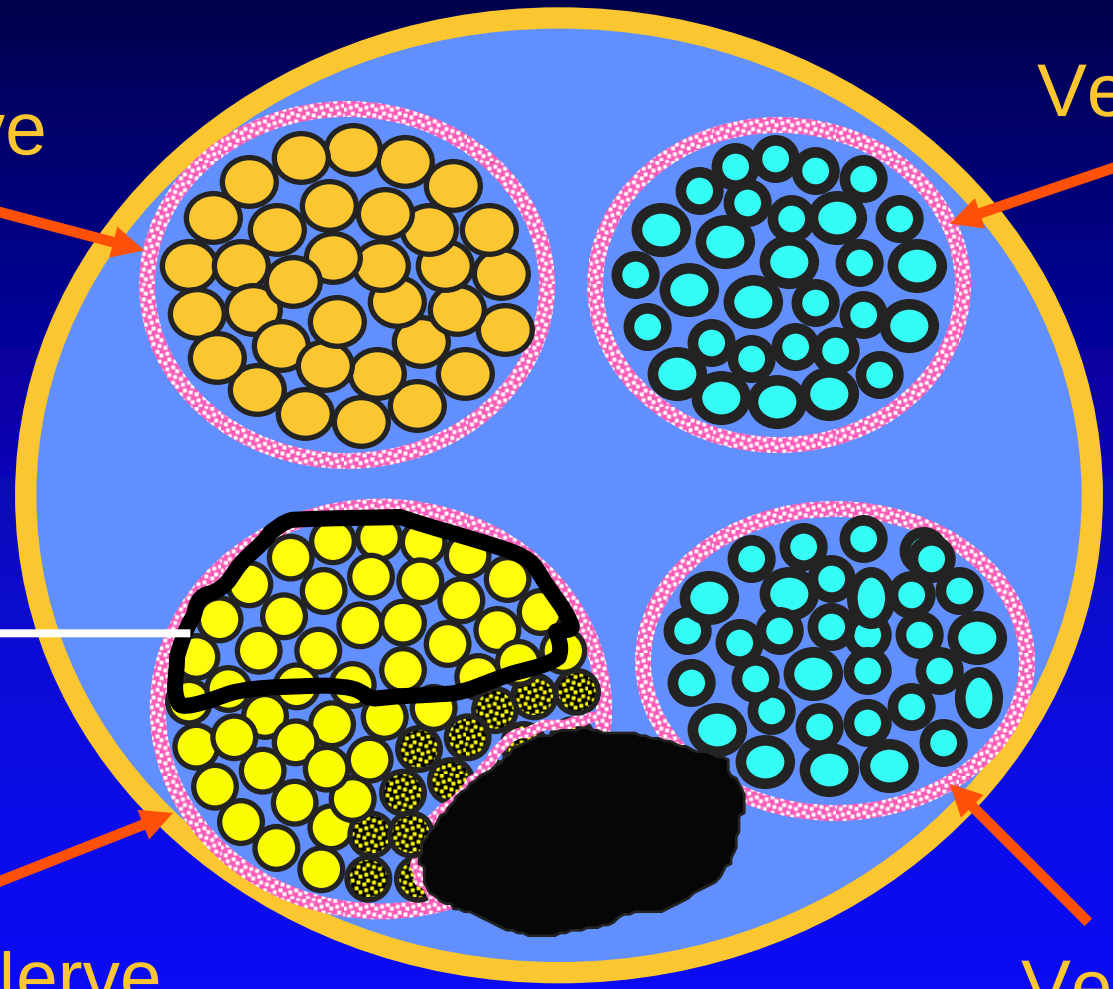
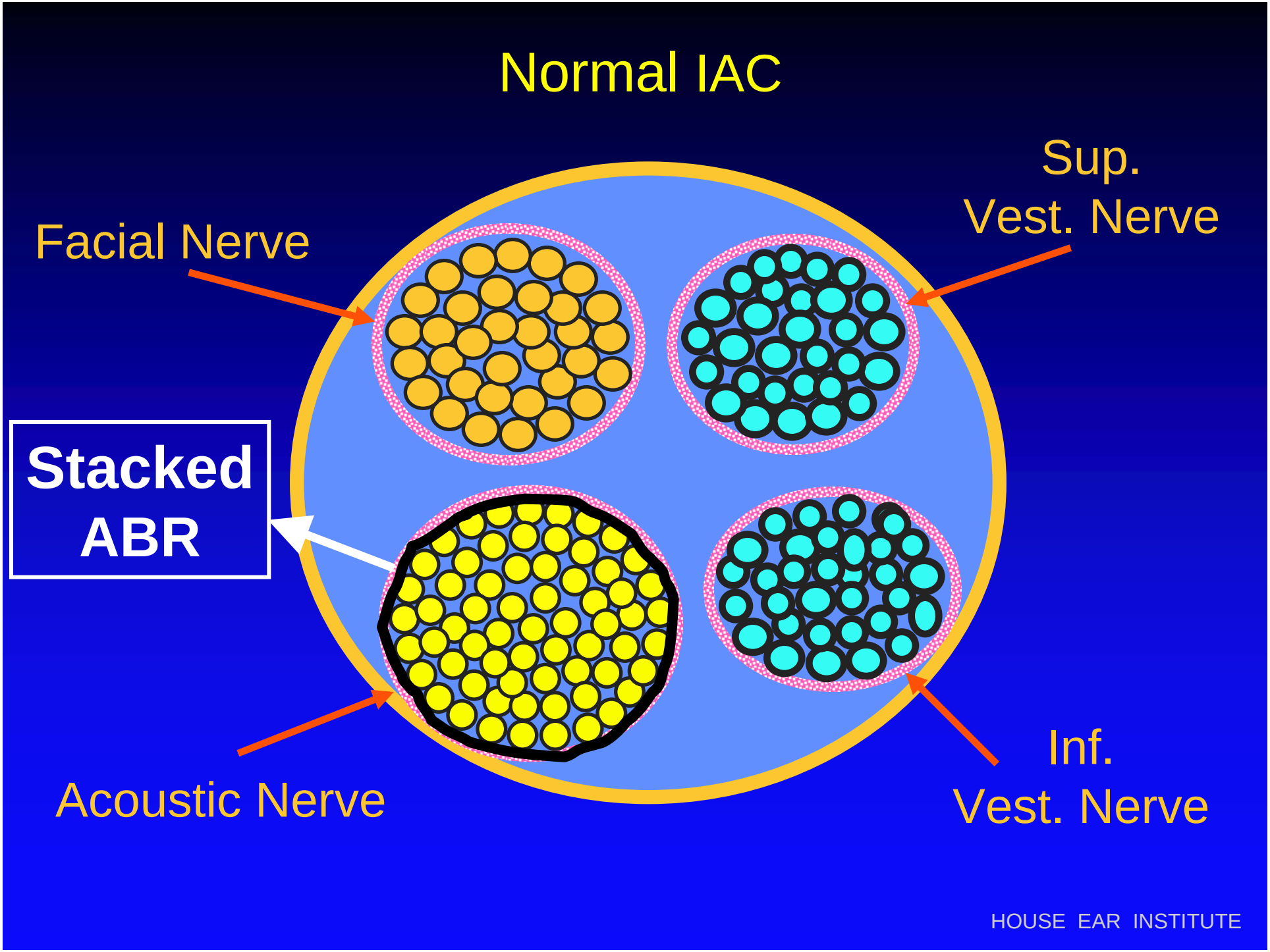
Small Tumor in IAC




Normal IAC
Facial Nerve
Sup.
Vest. Nerve
Stacked
ABR
Acoustic Nerve
Inf.
Vest. Nerve
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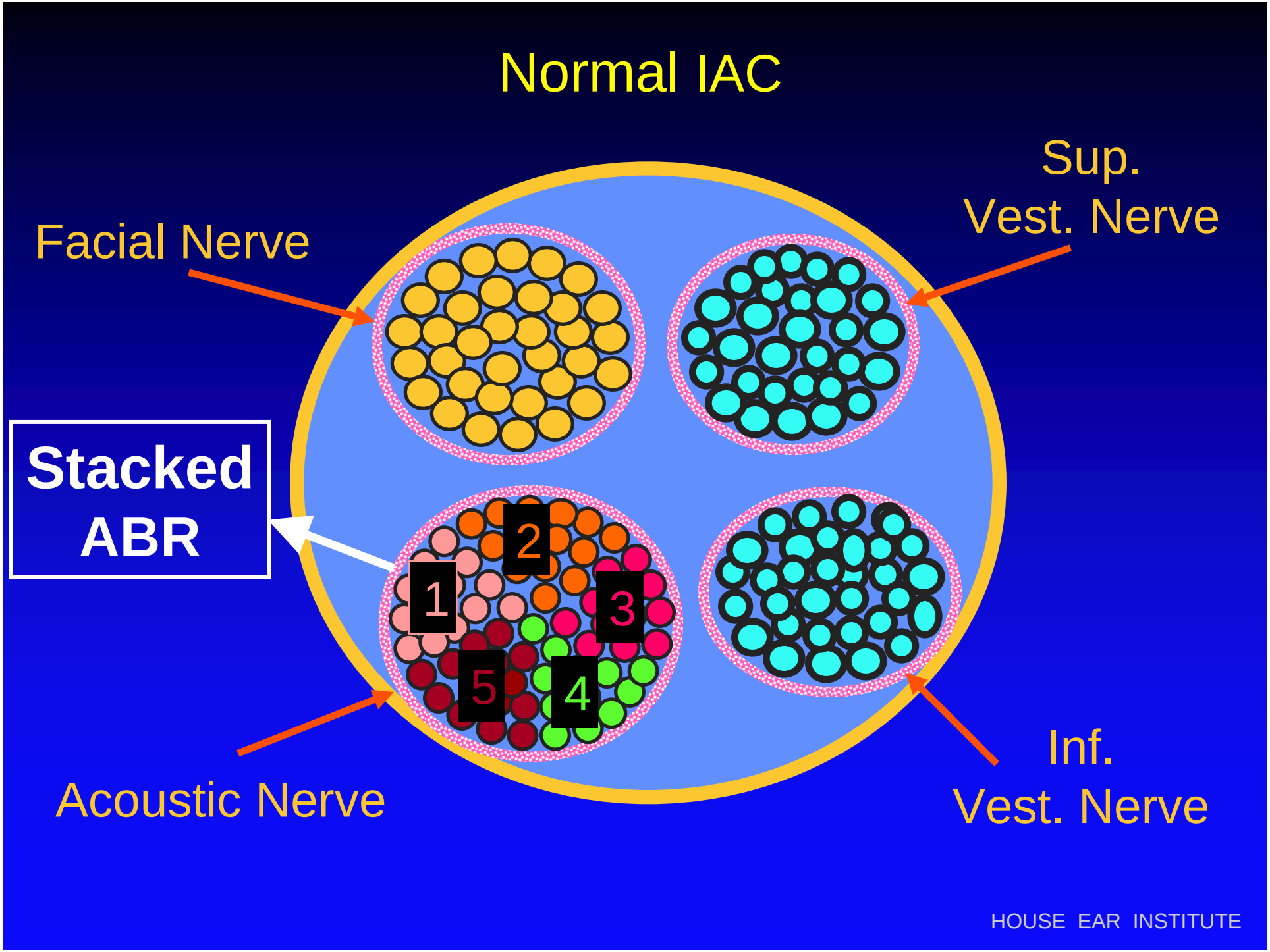
Normal IAC
Facial Nerve
Sup.
Vest. Nerve
Stacked
ABR
1
2
3
4
5
Acoustic Nerve
Inf.
Vest. Nerve
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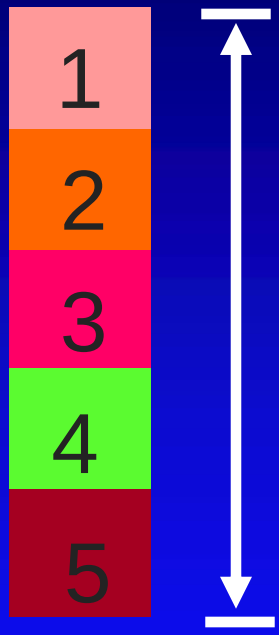
Diagnostic Test: If you add the activity from each of the five areas, is the amplitude normal?

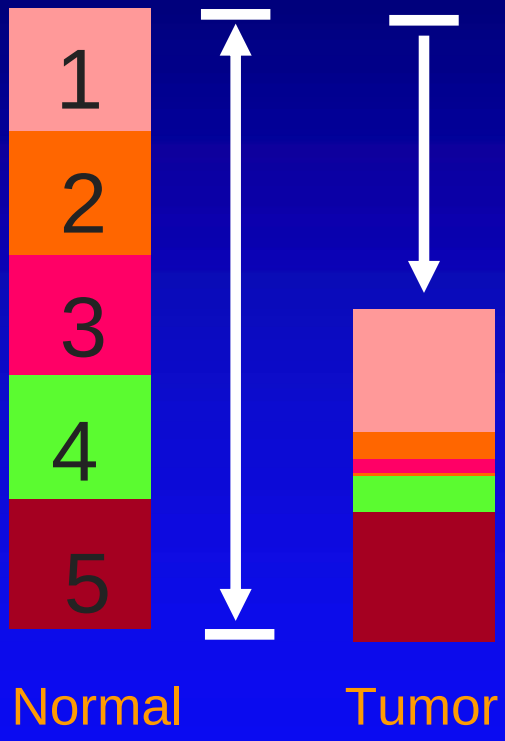
Activity from area 1
+
Activity from area 2
+
Activity from area 3
+
Activity from area 4
+
Activity from area 5

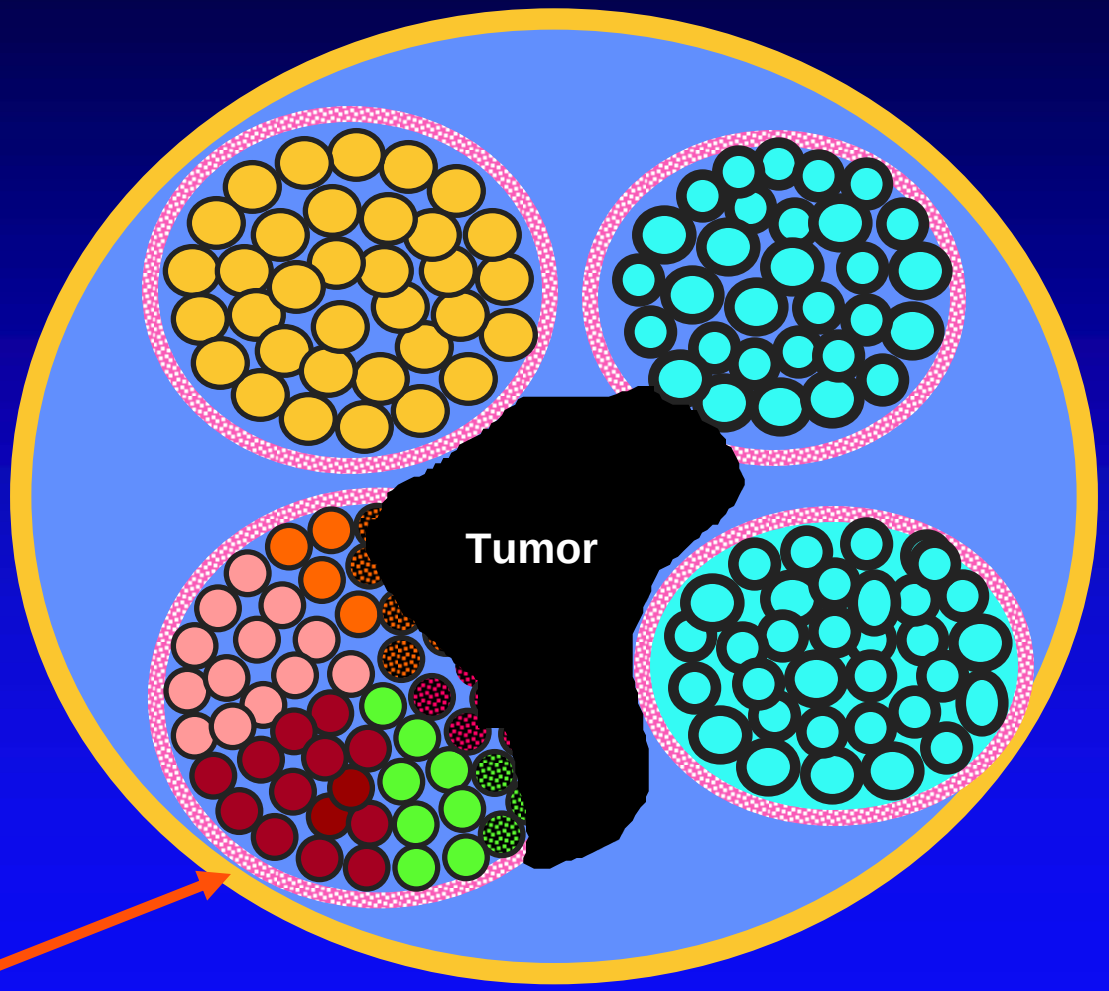


Normal Amplitude

Medium or Large Tumor in IAC

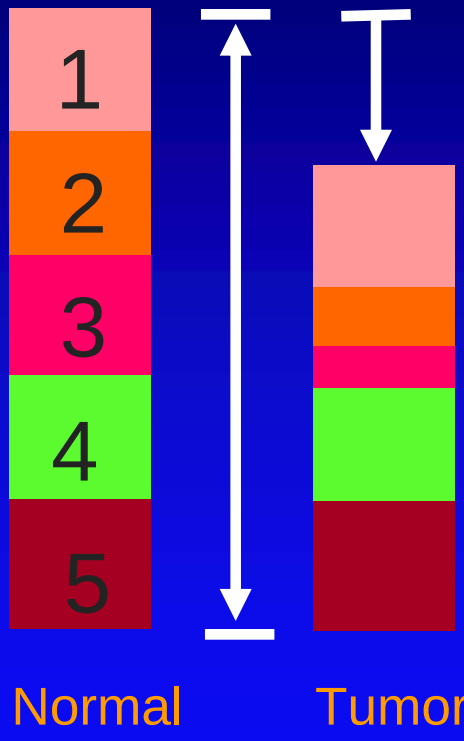
Abnormal
Stacked ABR

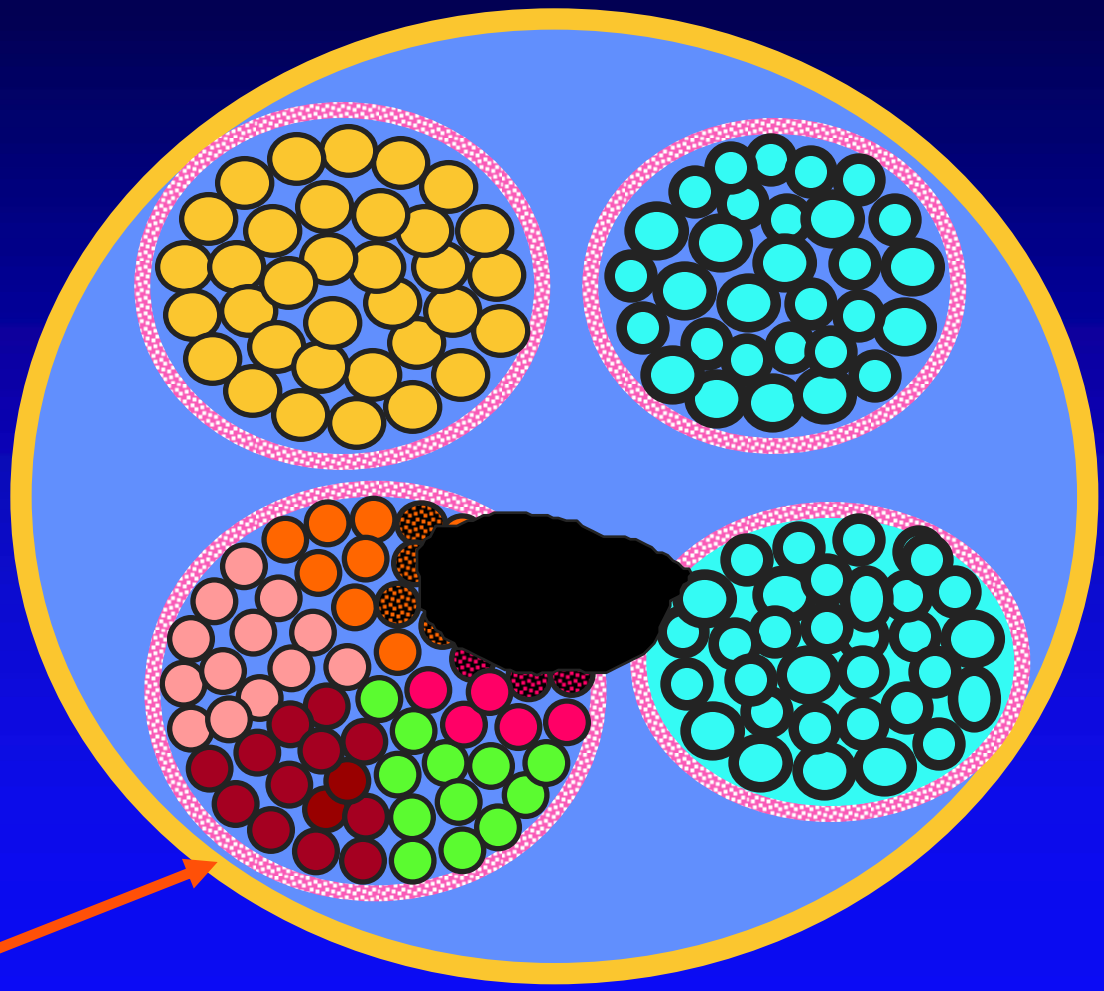




Small Tumor in IAC

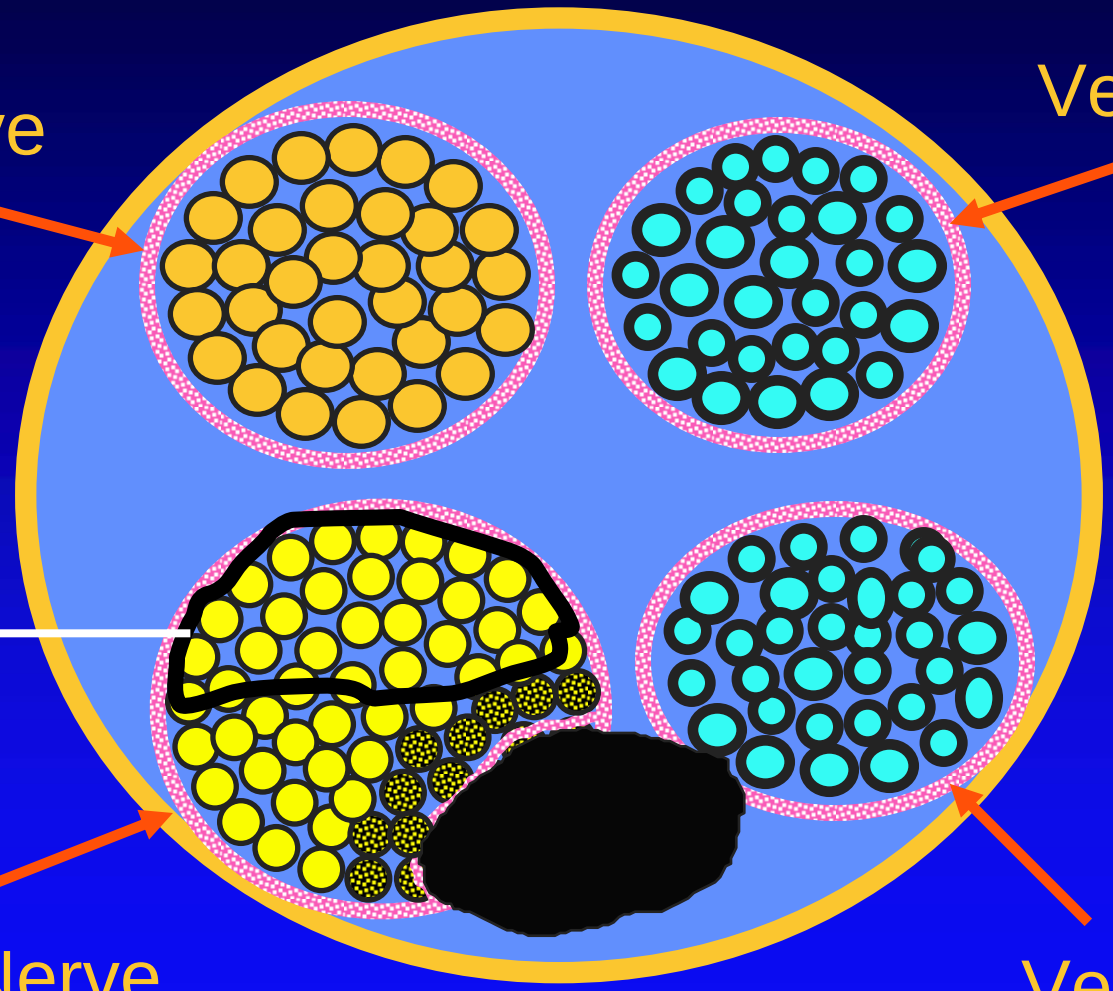
Abnormal
Stacked ABR





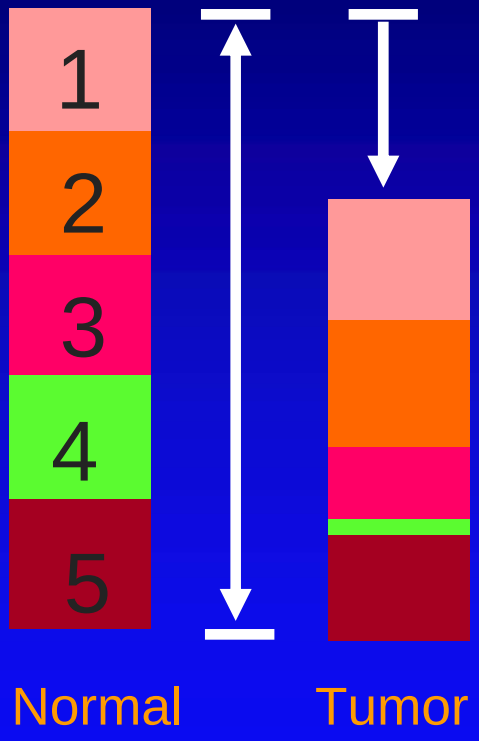
Acoustic Nerve

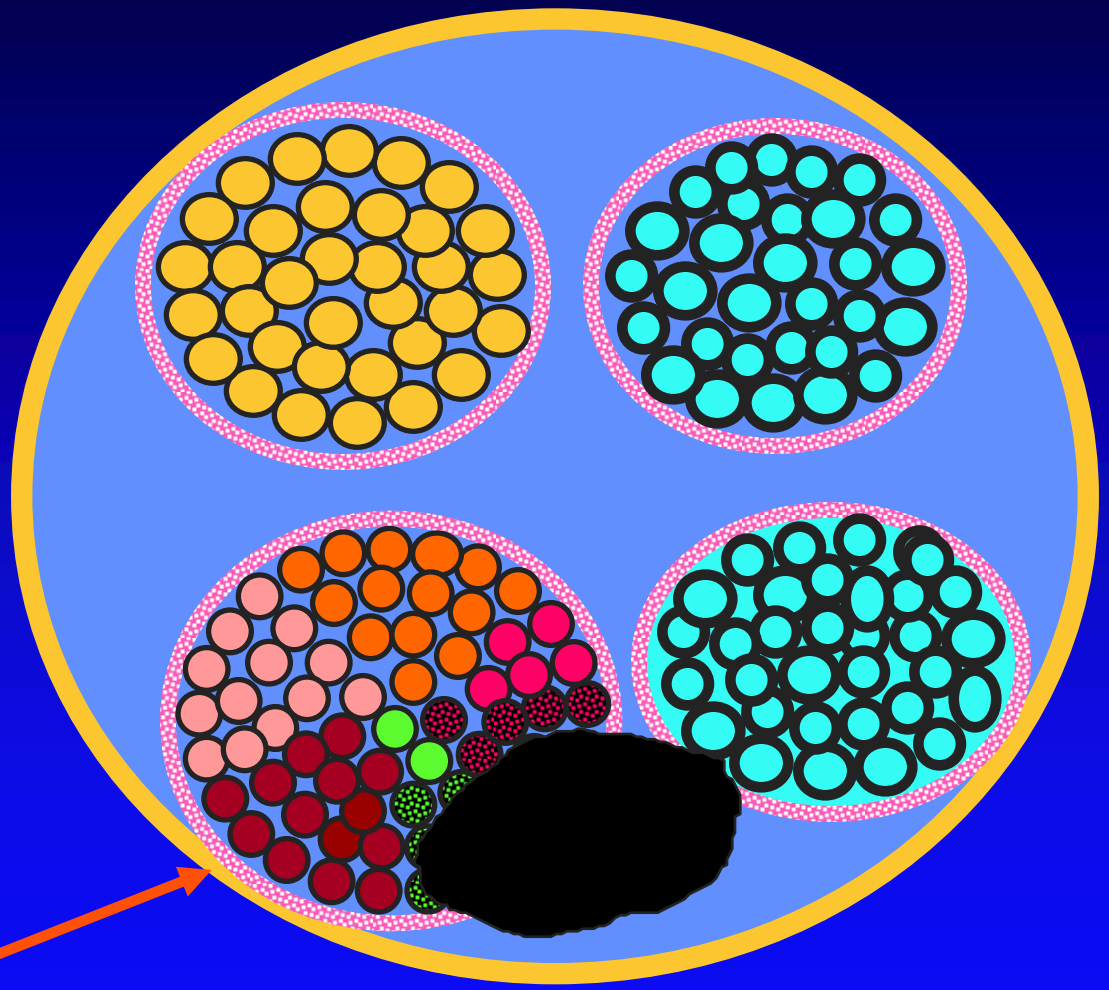
Small Tumor in IAC Missed by Standard ABR



Small Tumor in IAC

Abnormal
Stacked ABR





Acoustic Nerve

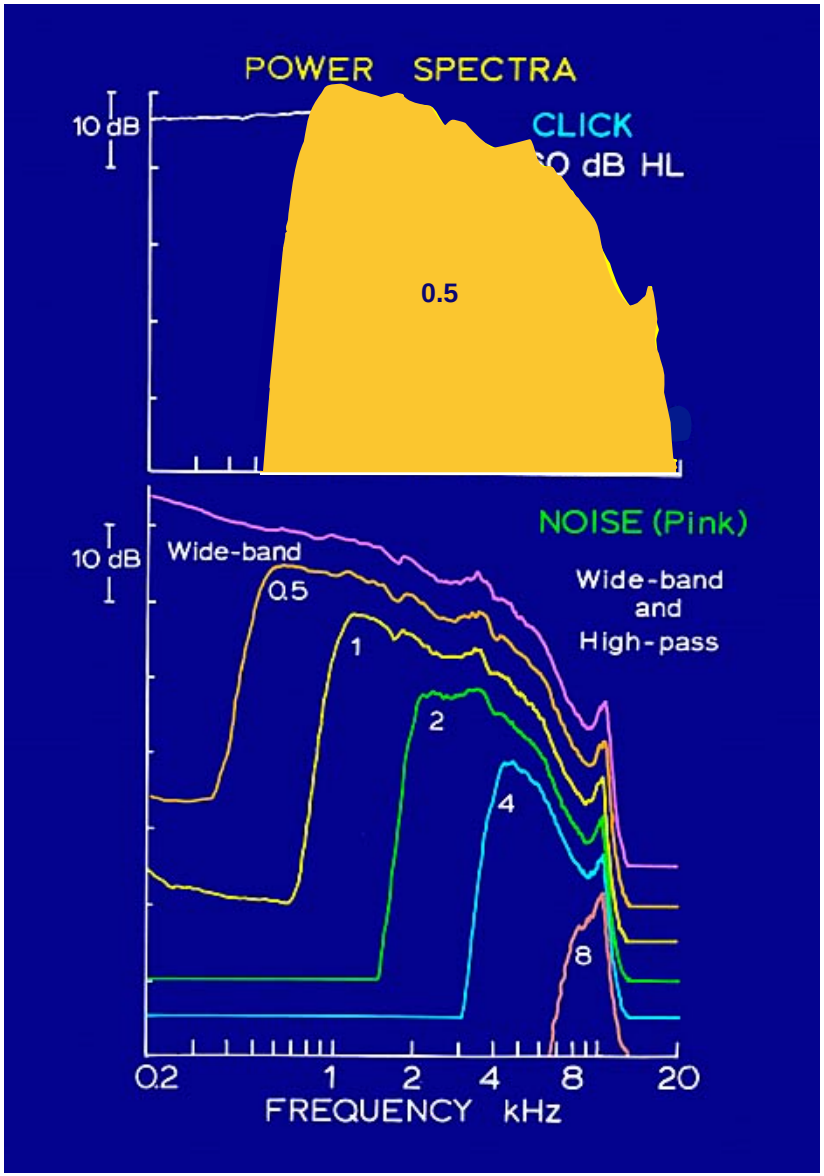
Stacked ABR Measure

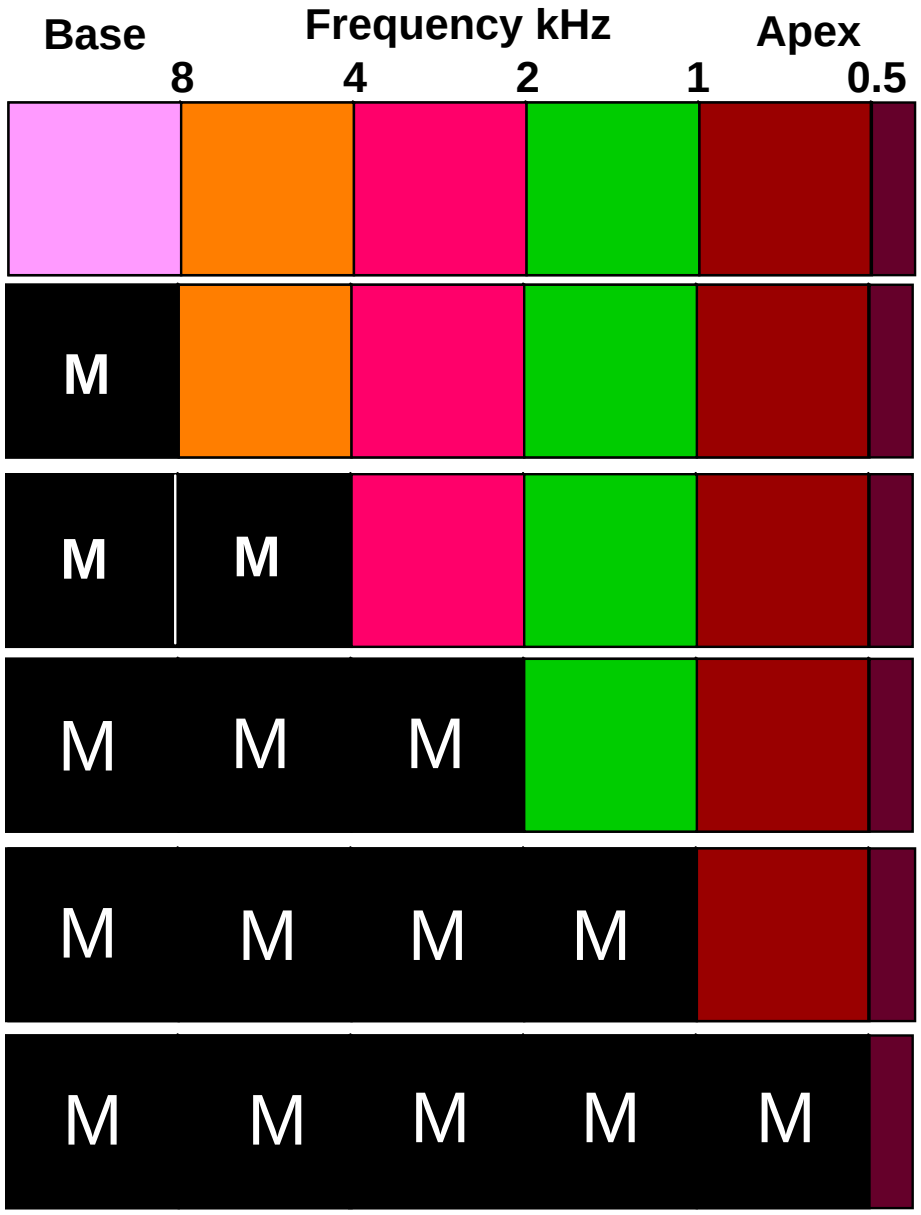
Requirements		Proposed Methods
1. An auditory signal that stimulates essentially all frequency regions of the cochlea	=>	Wide-band Click
2. A method for separating the responses from different frequency regions of the cochlea	=>	The Derived-band ABR Technique
3. A procedure for summing the responses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

TDH-49

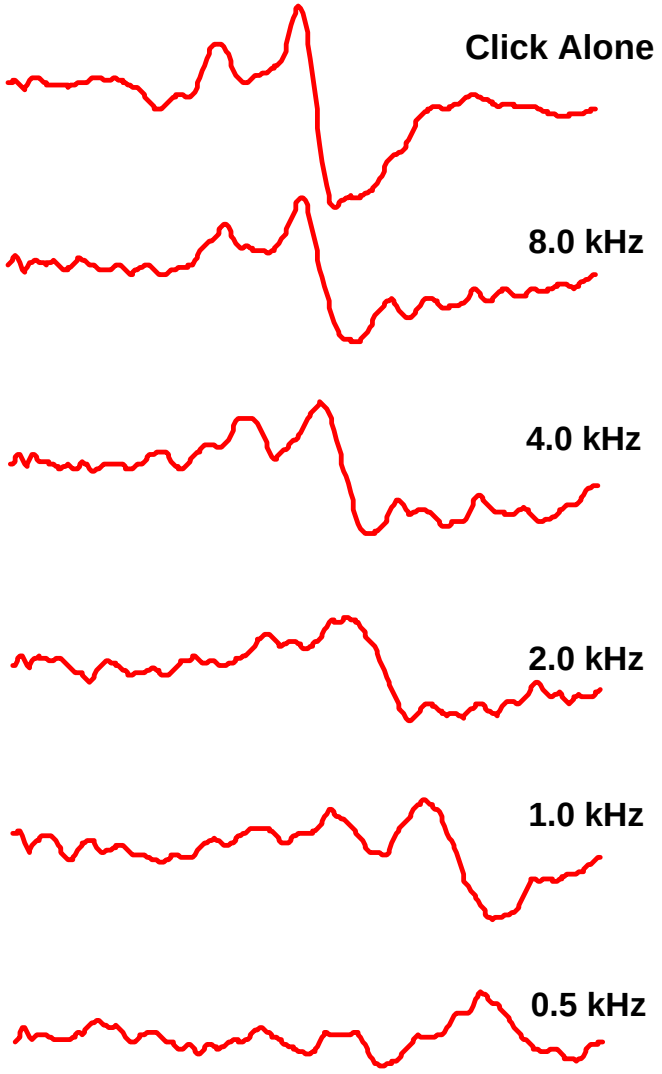
Click

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



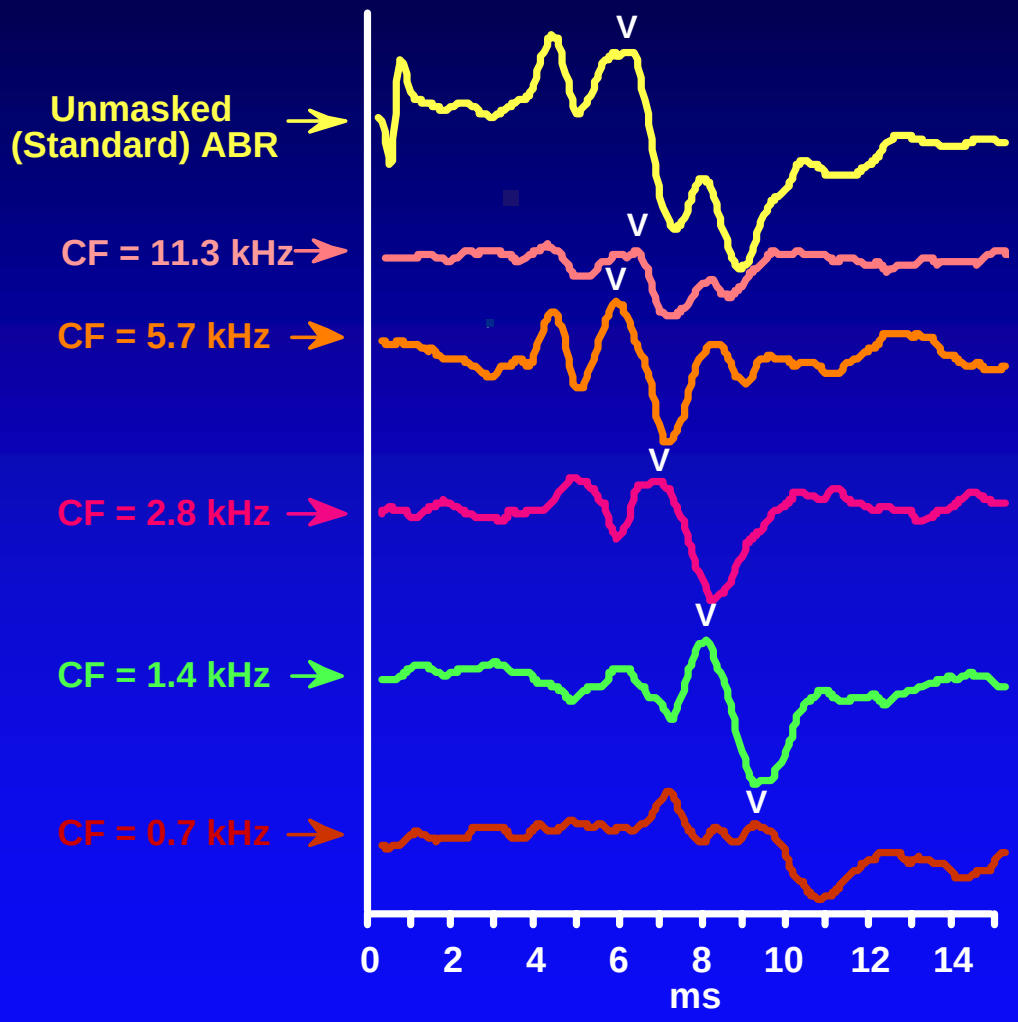


Click Alone and High Pass Noise Responses



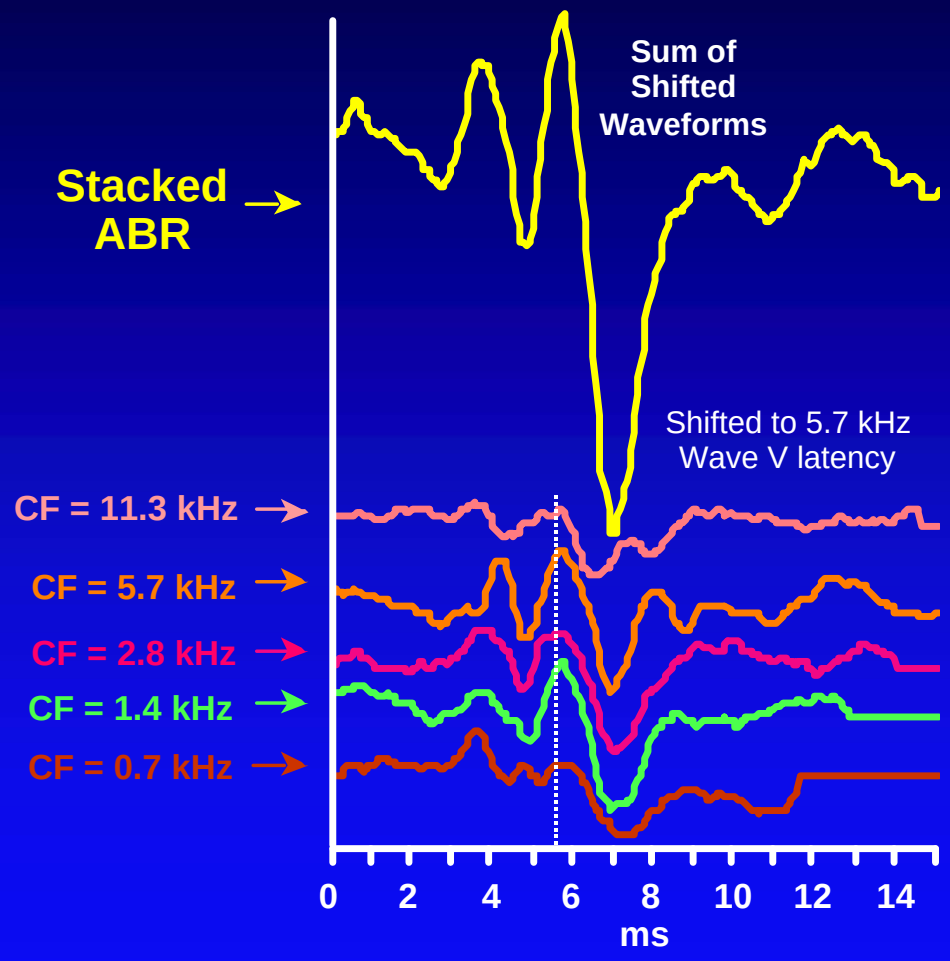
The Derived-band ABR Technique

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.

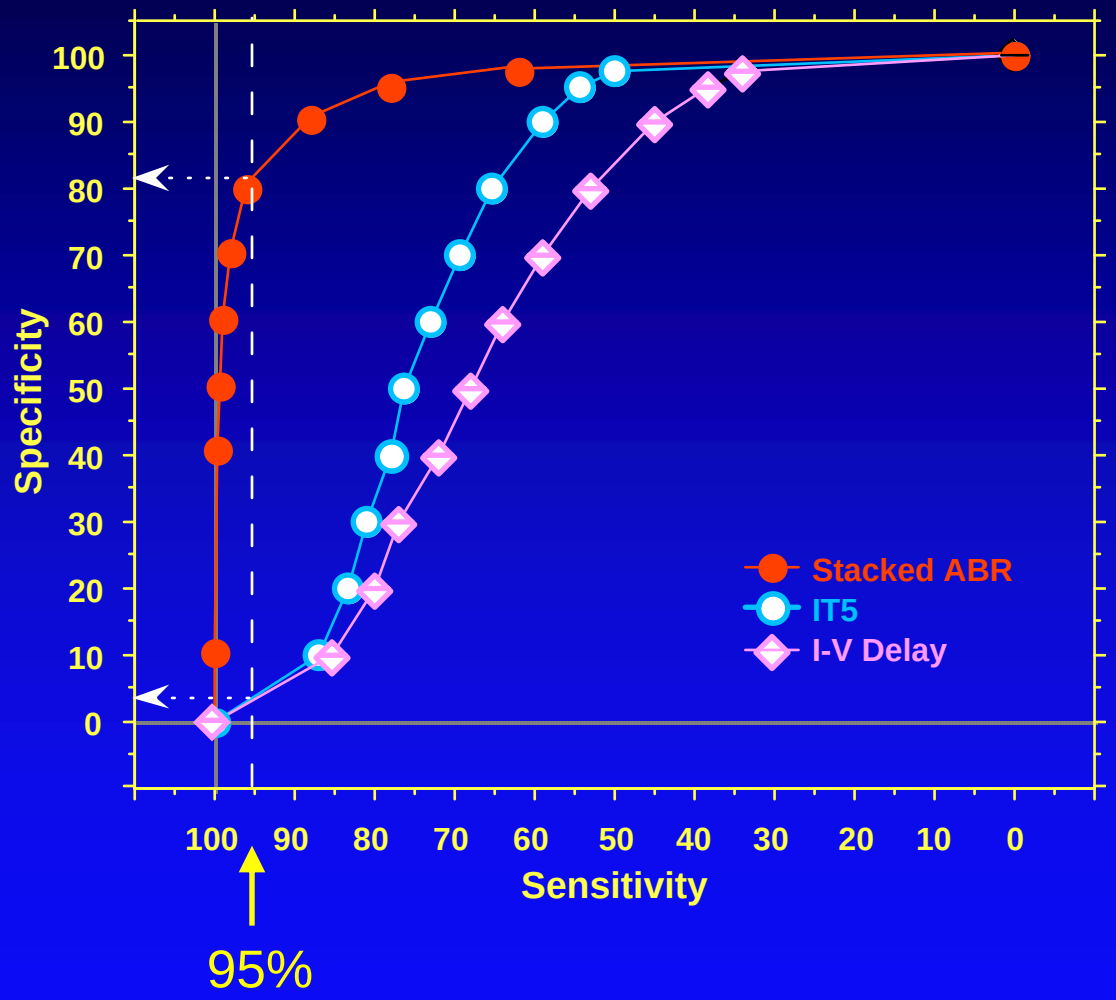


The Stacking Technique

- 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),

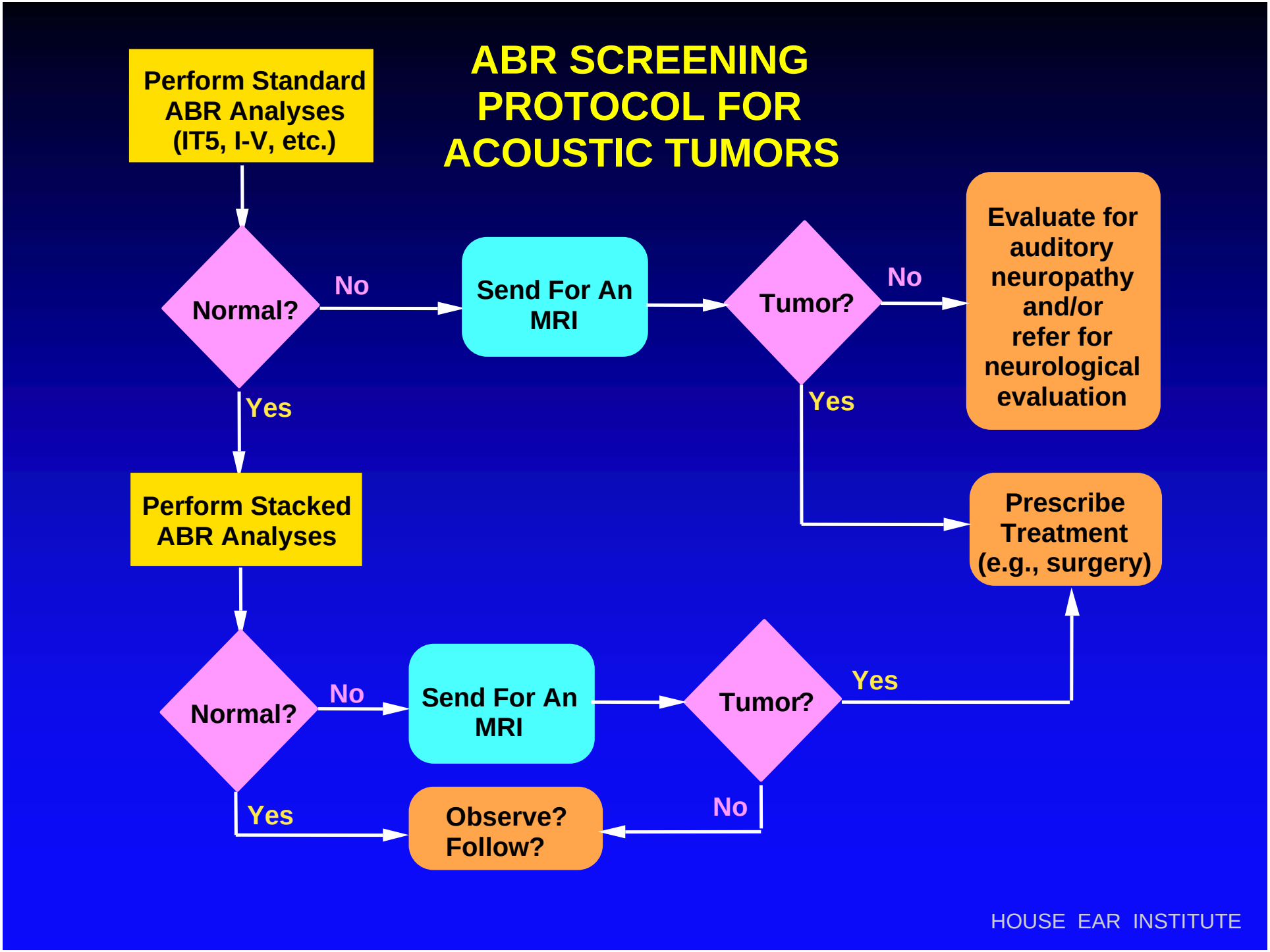
But the Stacked ABR has 83% specificity
(that is, the Stacked ABR correctly identifies 83 out of every 100 non-tumor patients)!

CONCLUSION

The Stacked ABR appears to have better sensitivity and specificity than the standard ABR for small (≤ 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
Perform Standard ABR Analyses (IT5, I-V, etc.)
Normal?
No
Send For An MRI
Tumor?
No
Evaluate for auditory neuropathy and/or refer for neurological evaluation
Yes
Yes
Perform Stacked ABR Analyses
Prescribe Treatment (e.g., surgery)
Normal?
No
Send For An MRI
Tumor?
Yes
Yes
No
Observe? Follow?
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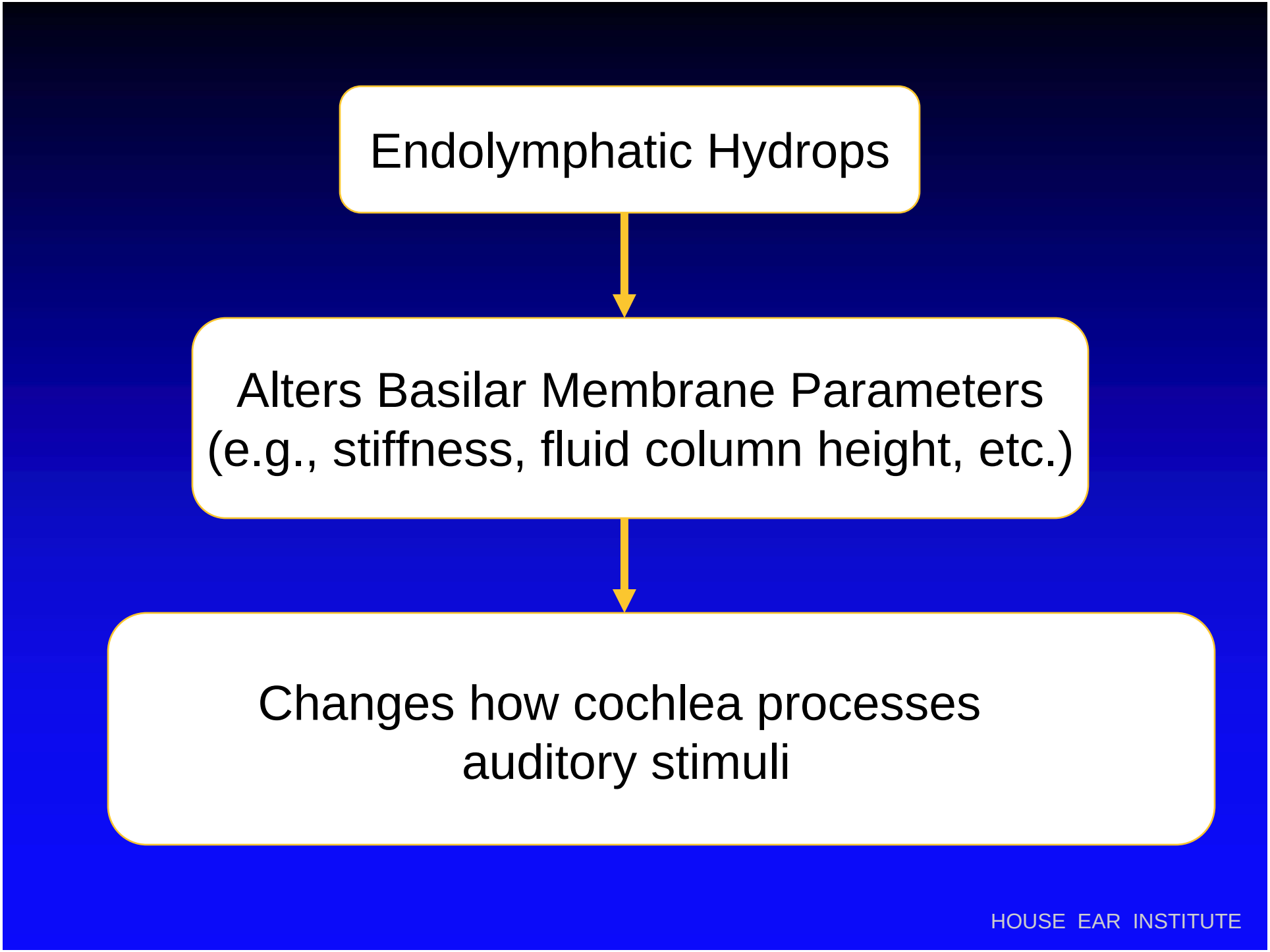
Breaking News: Meniere's Disease

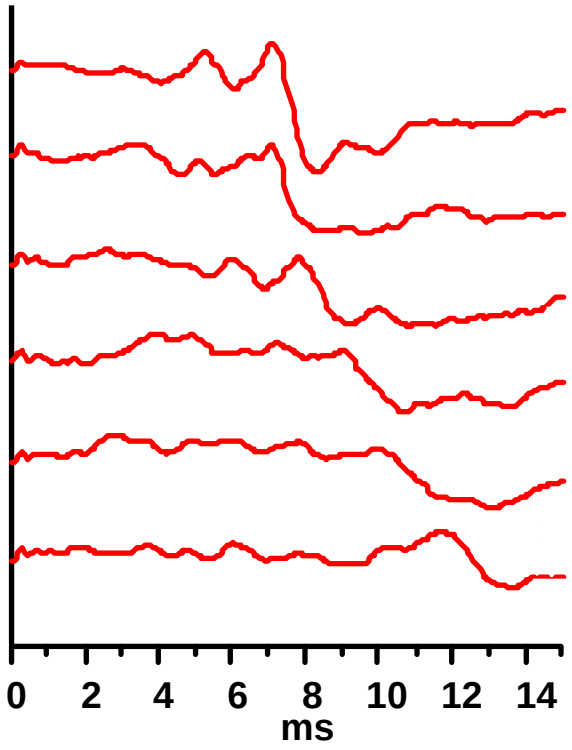
- Symptoms of early Meniere's disease and small acoustic tumors are similar.
- There's a pattern in the high pass responses of patients with Meniere's disease that may be used to help with the differential diagnosis.


Endolymphatic Hydrops
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



ABR to Click Alone (unmasked)

ABR to Click + 8 kHz HPN

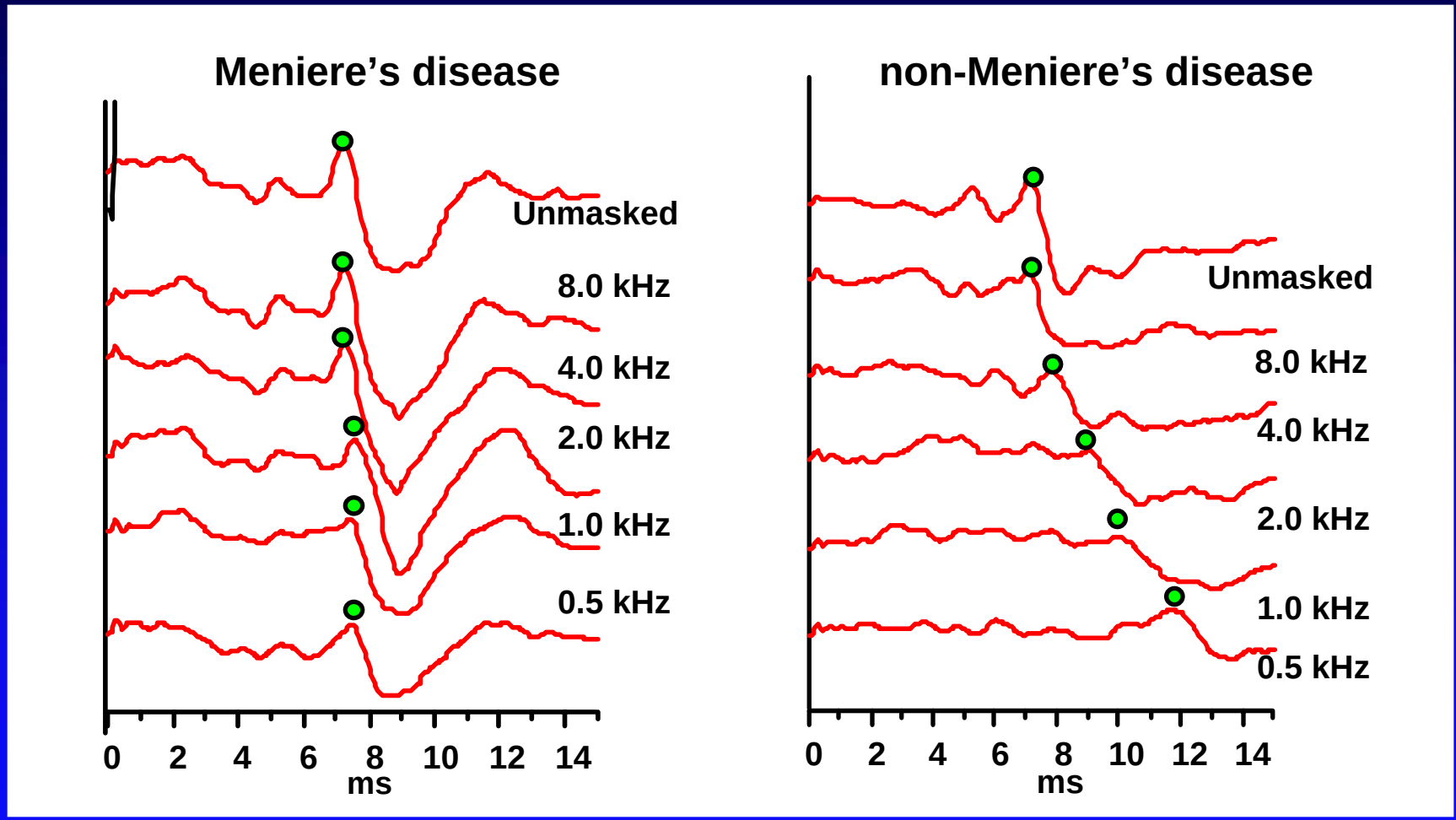
ABR to Click + 4 kHz HPN

ABR to Click + 2 kHz HPN

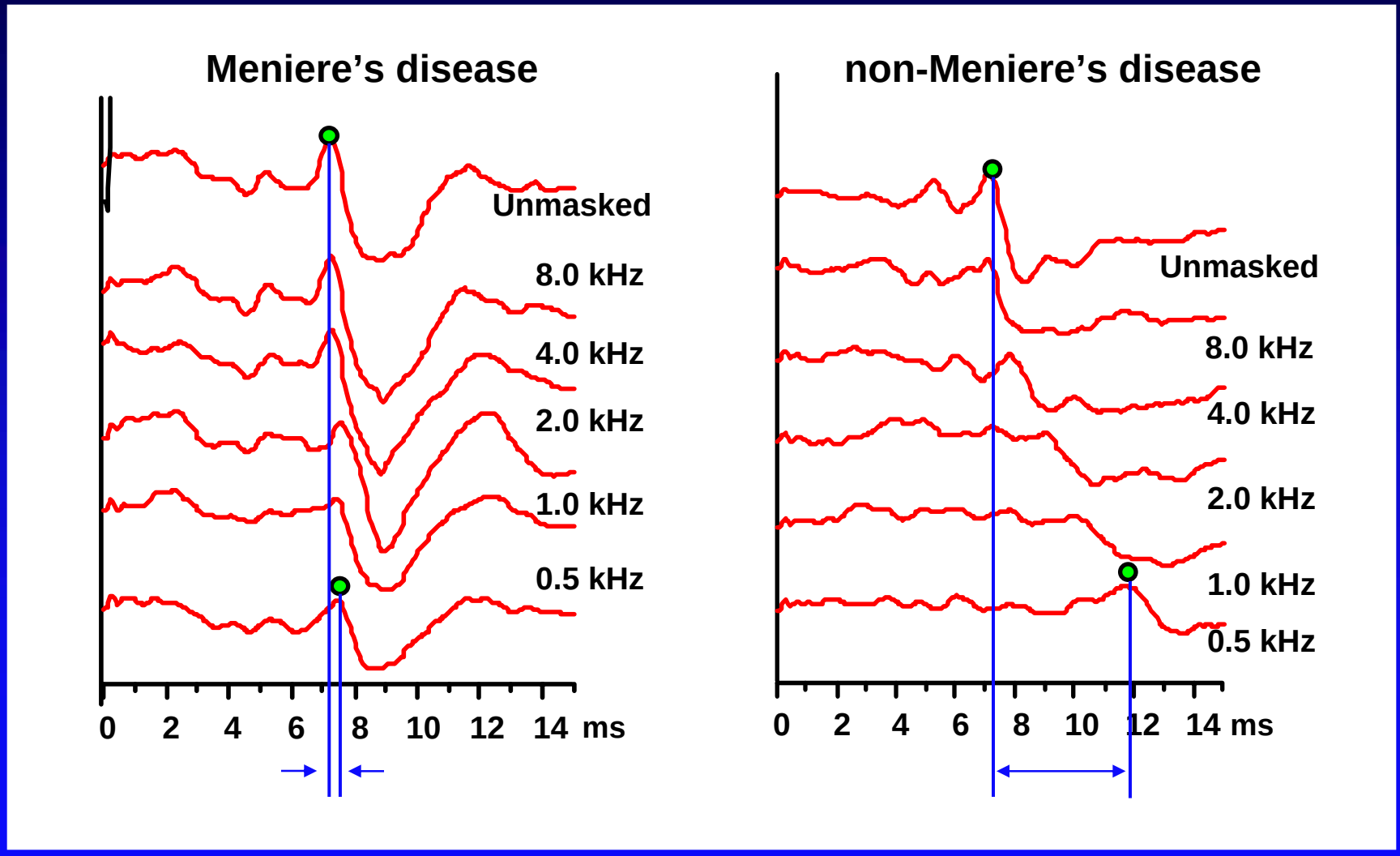
ABR to Click + 1 kHz HPN

ABR to Click + 0.5 kHz HPN

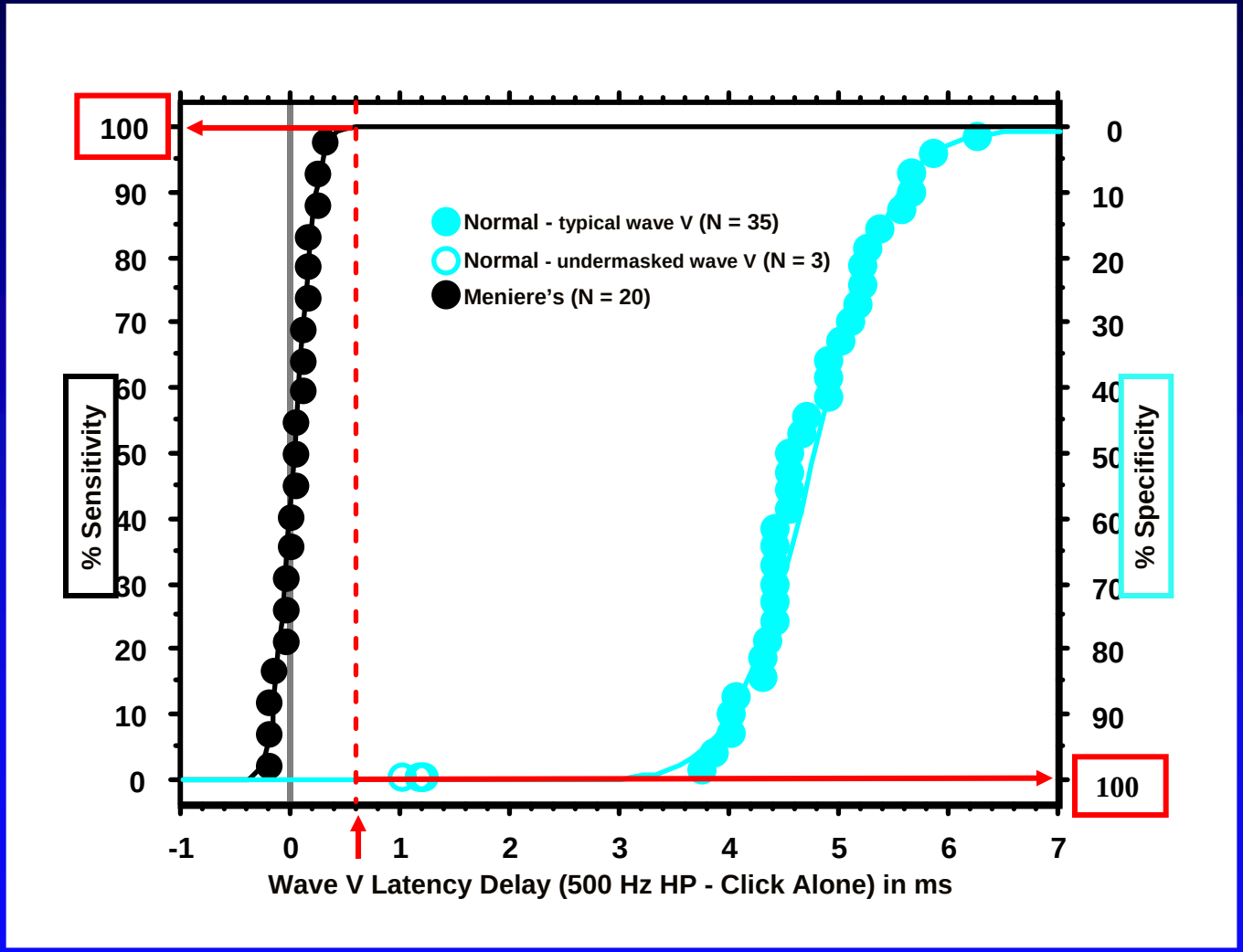
Undermasking in Meniere's Disease



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



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

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Support

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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.)