Abstract

Title: Using middle-ear reflectance and audiometry to diagnose conductive hearing loss
Presenters: Prof Jont Allen, Dr Patricia Jeng, Mr Joshua Hajicek; Mimosa Acoustics, Inc.

Middle-ear reflectance with audiometry can shed light on the difficult differential diagnosis for conductive hearing loss with an intact tympanic membrane and aerated middle ear, discriminating between ossicular *fixation*, ossicular *discontinuity*, and semi-circular canal *dehiscence* (Nakajima et al, 2012). Sensitivity and specificity were on par with a laboratory method using umbo velocity with audiometry. The reflectance measurement takes only seconds to make and is non-invasive. It allows for pre-surgical diagnosis of conductive hearing loss, which is a win for both clinician and patient. We will discuss the underlying physiology and physics behind these pathologies (to the extent we can) and discuss why the combination of audiometry and reflectance allows this differential diagnosis.

Outcome results:

1. Interpret audiometry and reflectance test results for ears with conductive hearing loss and an intact tympanic membrane and aerated middle ear.
2. For the three pathologies, describe the expected middle-ear reflectance pattern.

Reflections from the round window

Using middle-ear reflectance and audiometry to diagnose conductive hearing loss

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What is Impedance?

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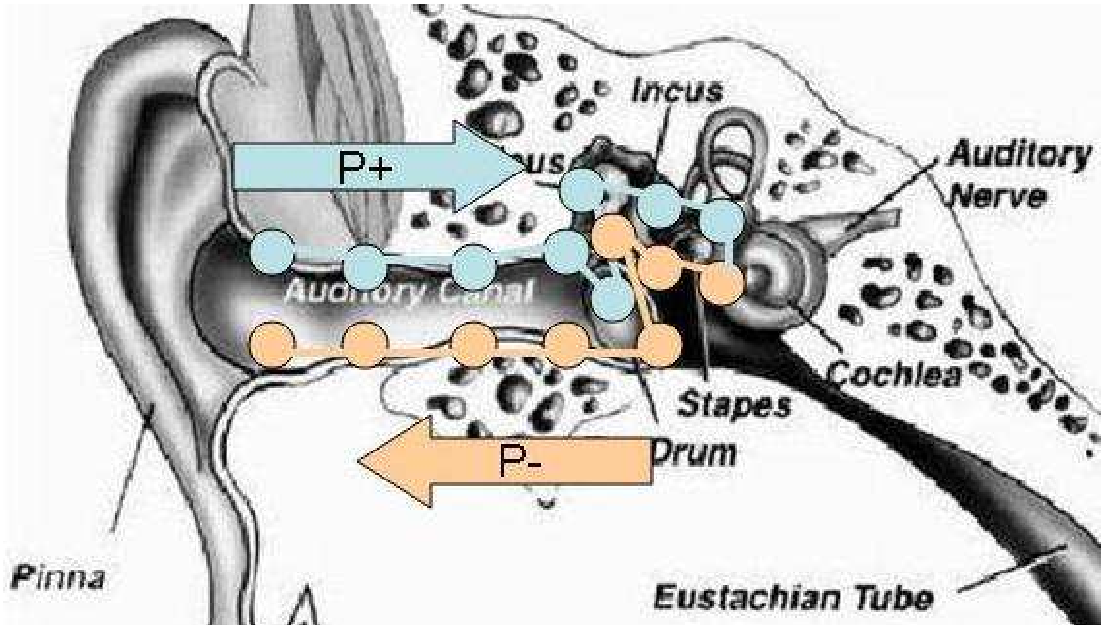
  - Tymps measured at a *few freqs:* e.g., 0.226, 1 kHz
  - **Mimosa's *Wideband Power Reflectance***:
    - Truly multifrequency: 0.2–6.0 kHz

What is *Wideband Power Reflectance*?



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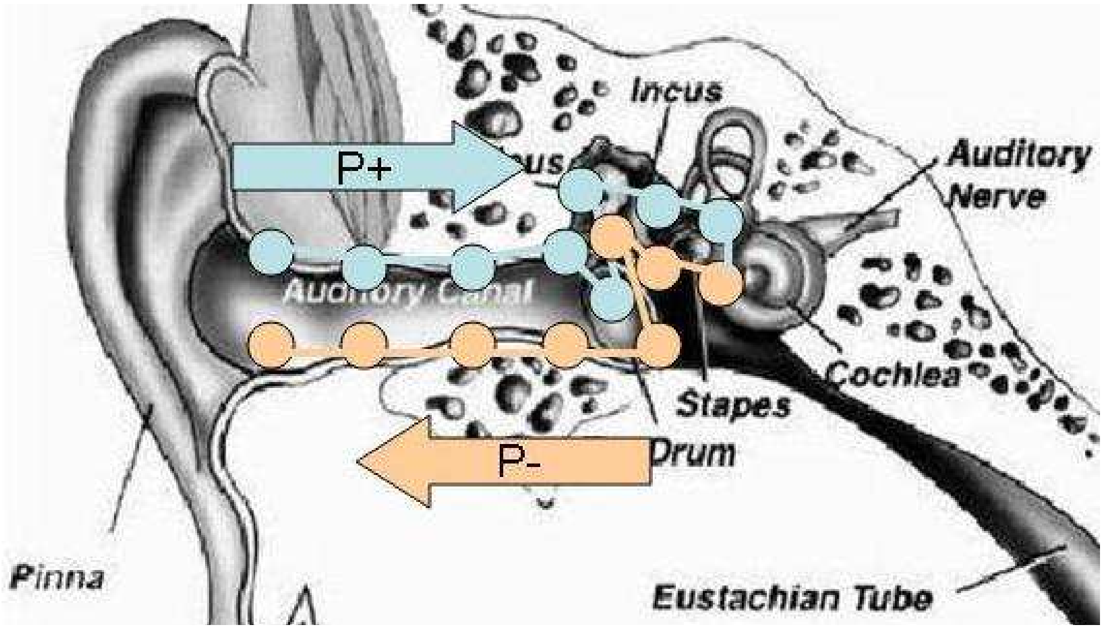
What is *Wideband Power Reflectance*?



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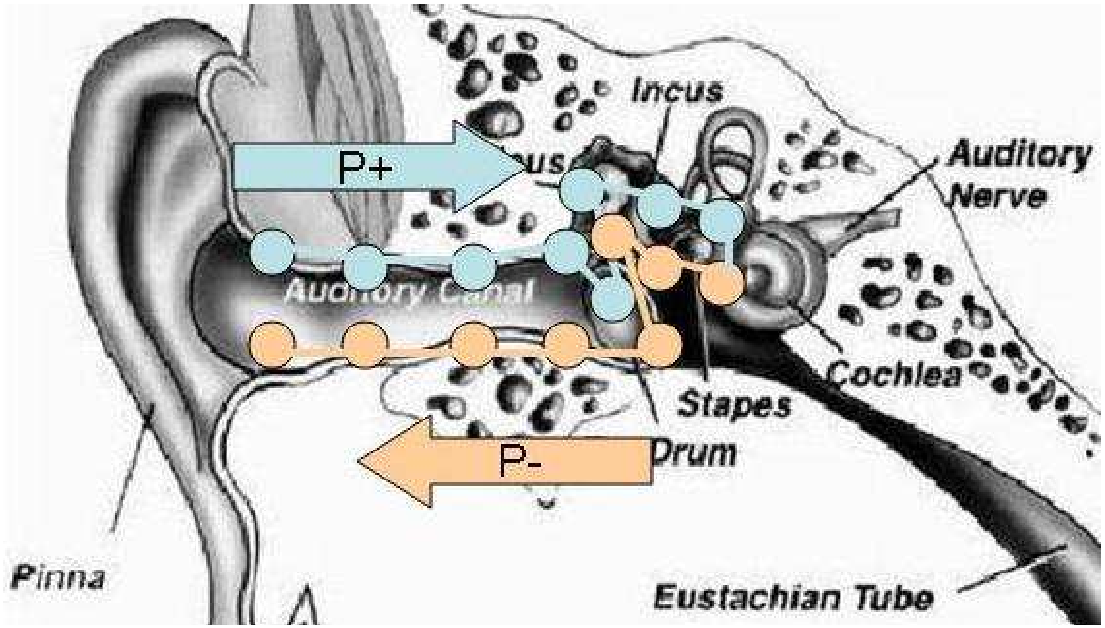

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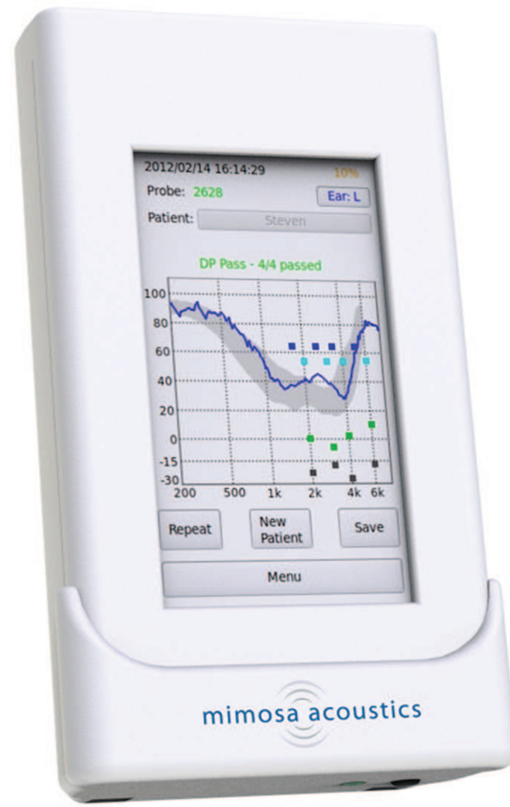
- Reflectance and impedance are functions of frequency, typically from 200–6000 Hz

Mimosa Acoustics' Otostat^{TM}

- *Acoustic Reflectance $\Leftrightarrow$ ME diagnostics*



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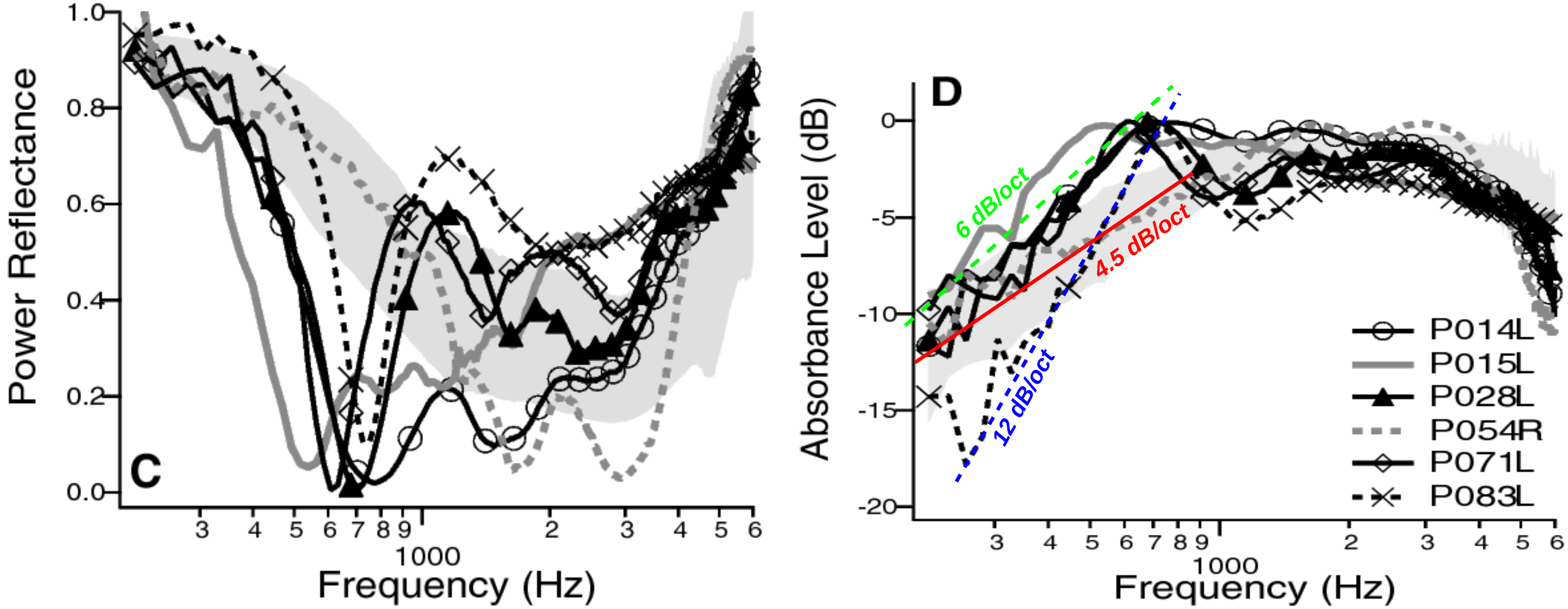
Tympanometry vs. Reflectance

Can Measure or Diagnose	Tymp	Reflect
Otitis Media with Effusion	Yes?	Yes
Ossicular discontinuity	No	Yes
Otosclerosis (stapes fixation)	No	Yes
TM Perforations	No	Yes
Hypermobile TM	No	Yes
Dehisence	No	Yes
Acoustic reflex	Yes	Yes
Bacterial biofilm	No	Yes
Canal Volume	Yes	Yes
ME volume	Yes	Yes
ME Static pressure	Yes	No

Recent Literature

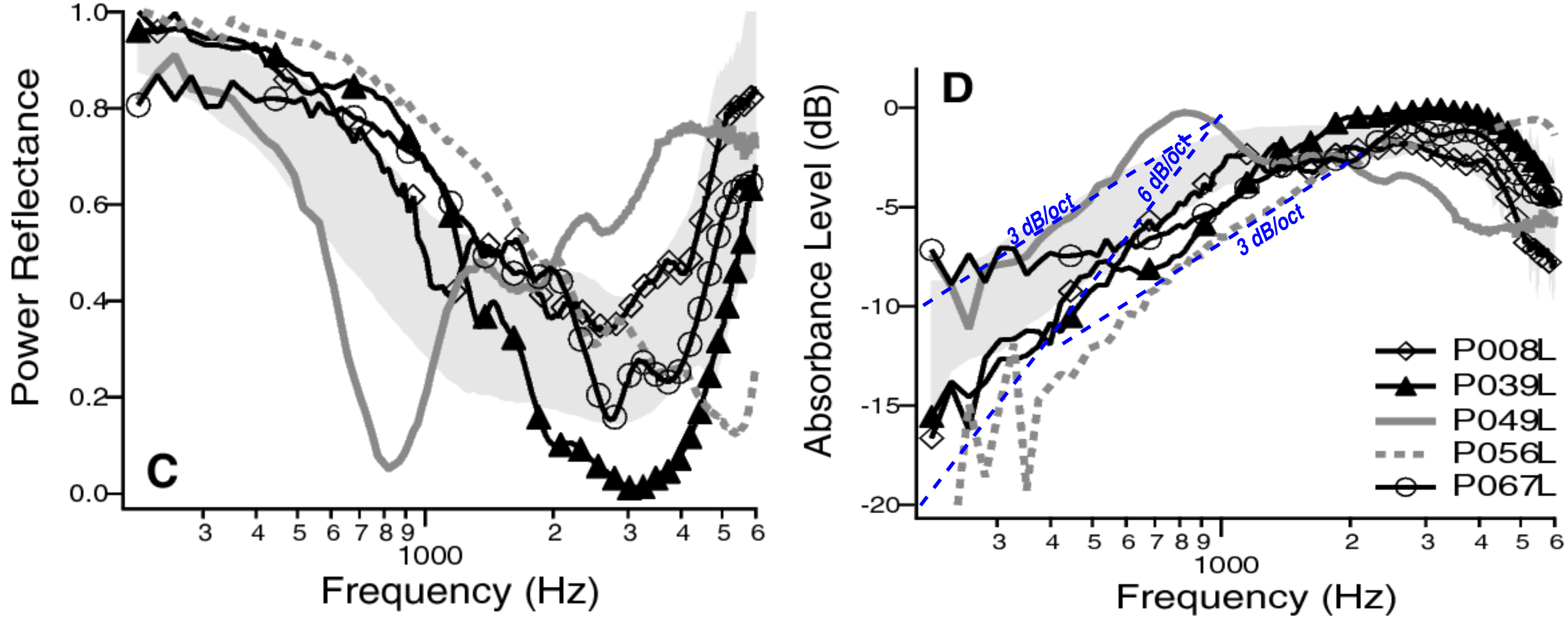
- Technique: Allen 86; Siegel 90; Keefe 93; Withnell 09;
- Results:
  - Temporal bones: Voss 01; Voss et al. 12
  - Newborns: Keefe & Norton 00; Hunter 10
  - Adults:
    - Normals: Voss & Allen; Scheperle; Shahnaz
    - Pathology: Feeney 04; Allen 05; Margolis 10; Nakajima et al. 2012
- Nakajima et al (2012) – Results on Ossicular:
  - Discontinuity (N=6)
  - Fixation (N=14)
  - Dehiscence (N=11)

Ossicular Discontinuity



- N=6 ears with *Stapes Discontinuity*
- Left: *lower* stiffness $\equiv$ Reflectance $[|\Gamma(f)|^2]$ *resonance*!
- Right: Absorbance ($\equiv 1 - |\Gamma(f)|^2$ dB) has higher slope
  - Slope 6-12 dB/oct (vs. normal ≈ 3 dB/oct)
- Lower stiffness + free mass $\Rightarrow$ resonance $\approx$0.5-0.8 kHz
- A few ears different (multiple pathologies?)

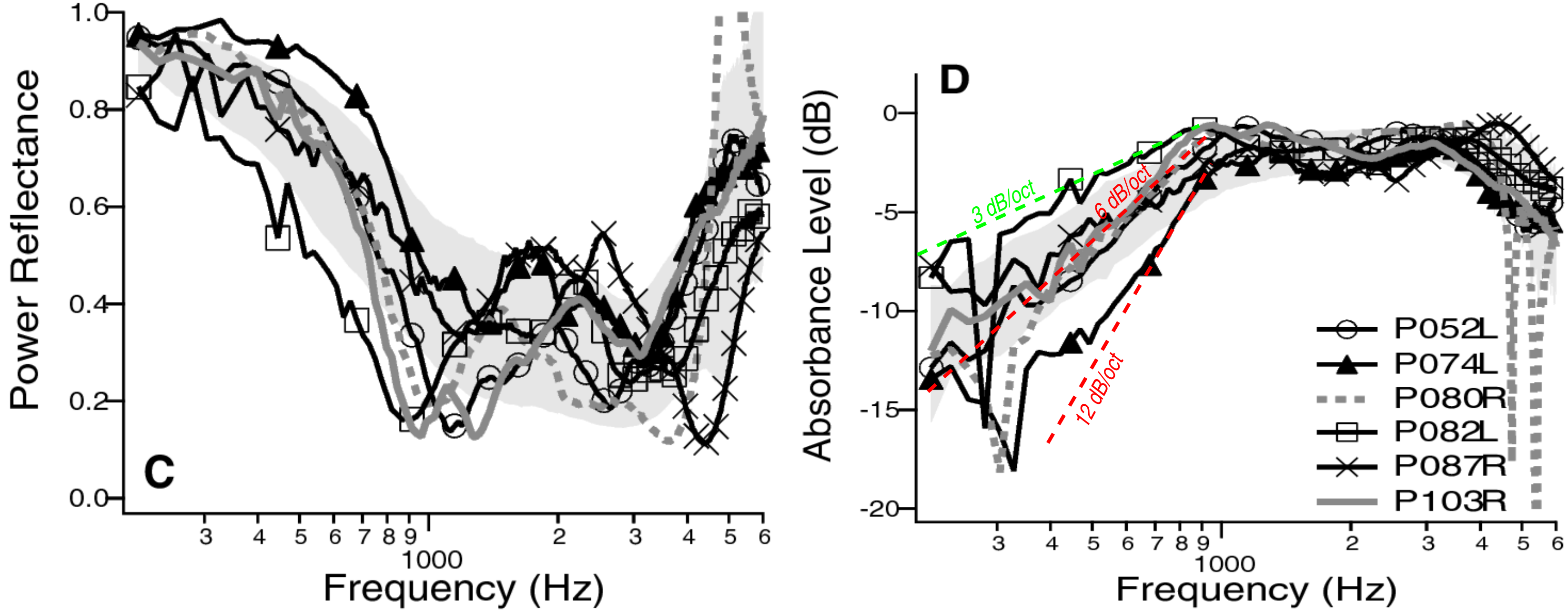
Ossicular Fixation



- Five representative (of 11) with Stapes Fixation
- Left: Four of five show a small increase in stiffness
- Right: Absorbance data show this most clearly
- Not shown: Umbo Velocity is decreased ($\approx$ 10 dB)
- What going on? Stiffness increase due to fixed stapes
- One ear (of 11) very different (discontinuity?)

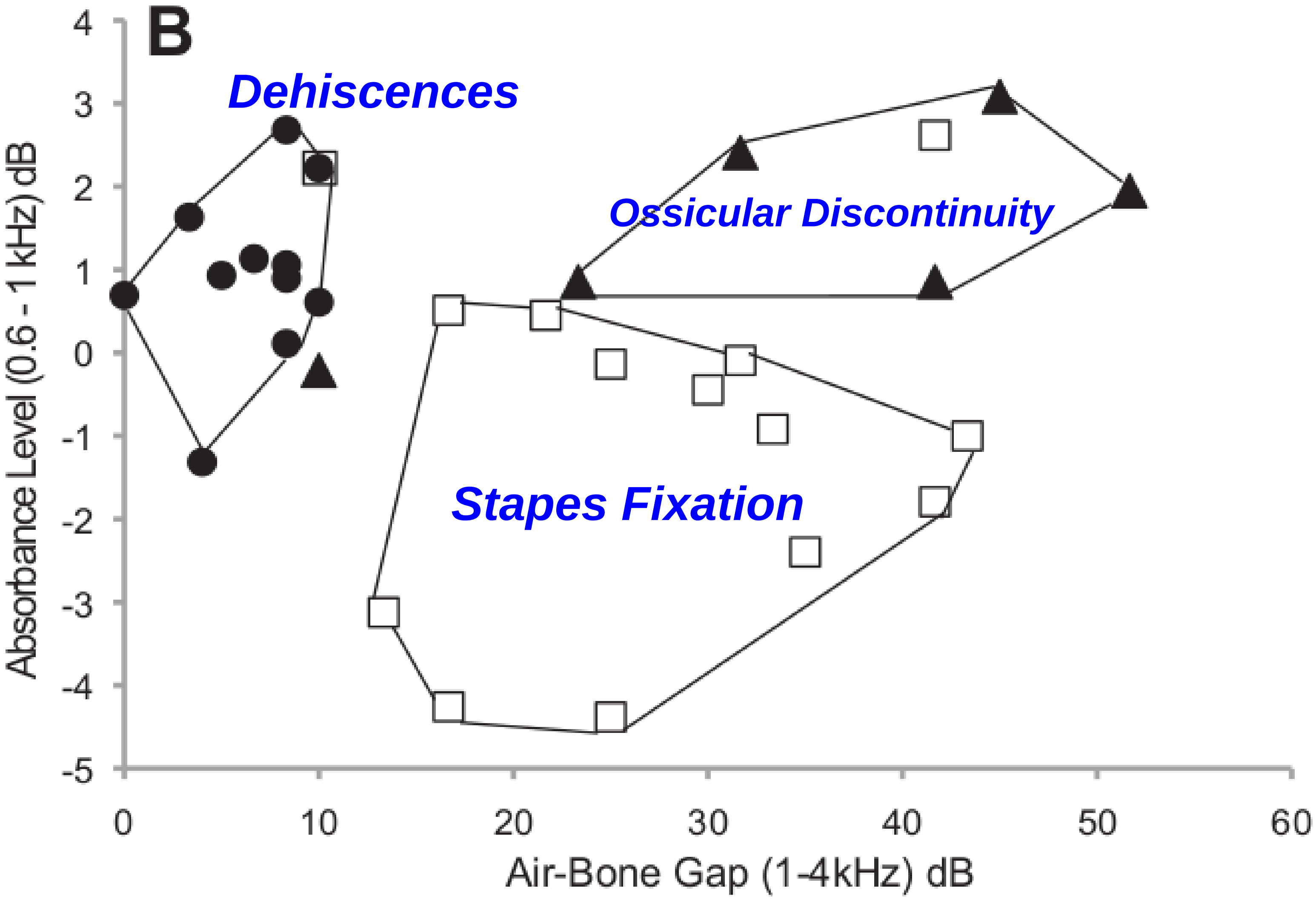
uperior Canal Dehiscence & cholesteatom

Superior Canal Dehiscence



- Six ears (of 11) with Dehiscence
- Left: Reflectance
- Right: Absorbance
- Clear resonance around 1 kHz
- Not shown: Air bone gap is modest (<10 dB)
- Whats going on? The jury is still out

Diagnostic Evaluation



- Separation via Absorbance and Air-bone conduction
- Note: All 31 ears have healthy TM & aerated ME

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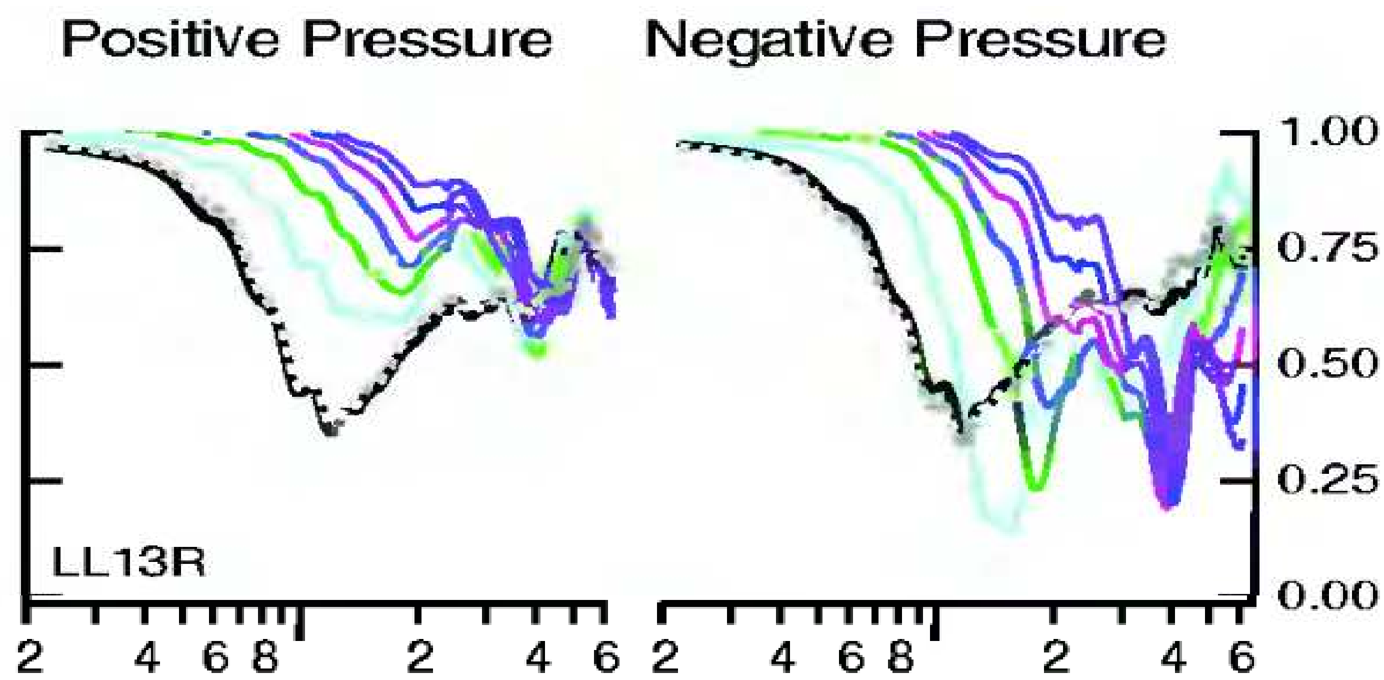
    - Pathology: Feeney 04; Allen 05; Margolis 10; Nakajima et al. 2012
- Voss, Merchant & Horton (2011)
  - Middle ear pressure (N=8)

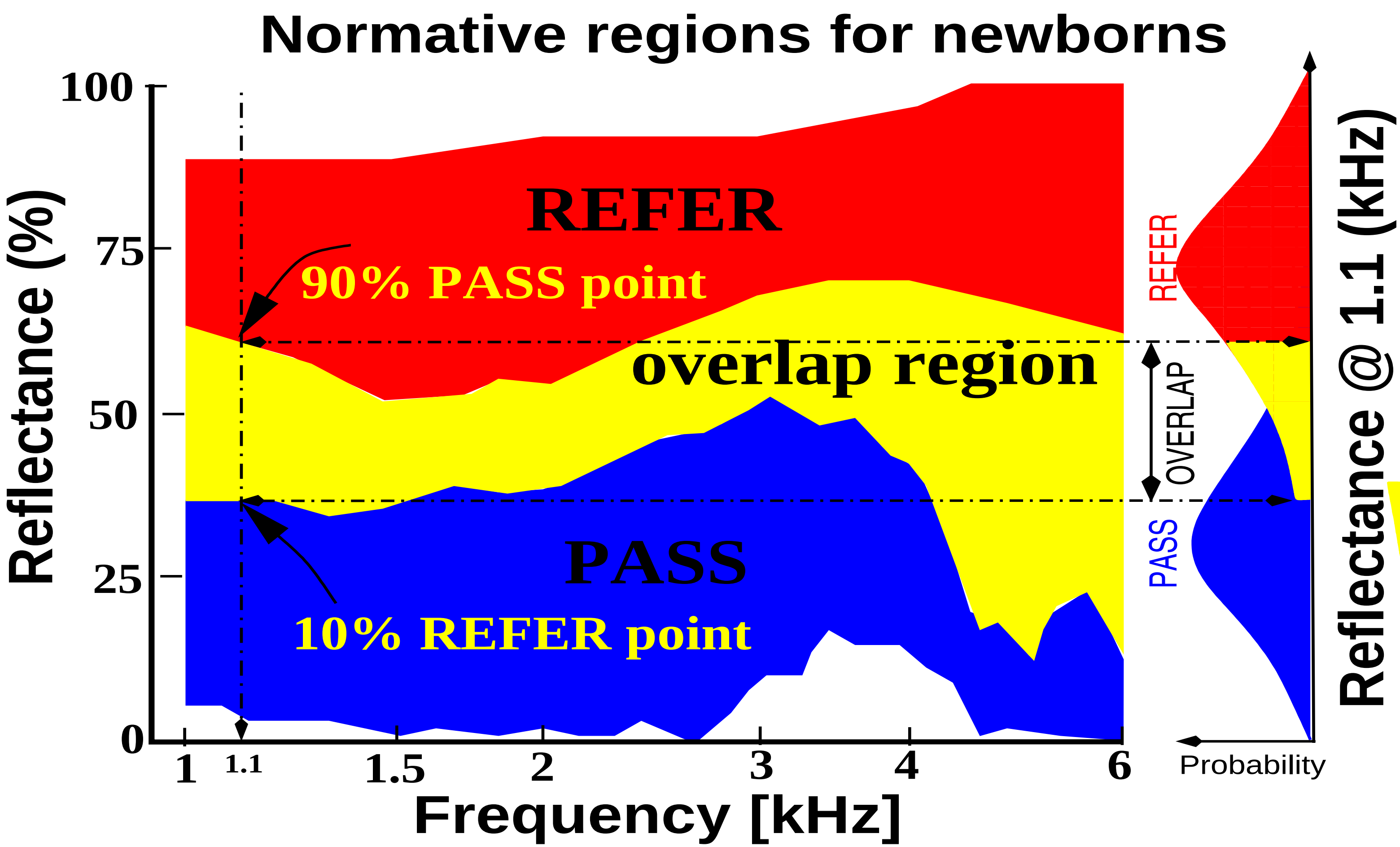
ME pressure and Power Reflectance



- Positive & Negative pressure (50 dPa steps)
- Whats going on?
  - ME pressure dramatically changes TM stiffness
  - Easily observed in the Power Reflectance
  - +Pres Stretches vs. -Pres compresses joints

Correlation with DPOAE test results

- Excellent False-positive DPOAE detection
  Hunter et al., 2009; Sanford et al., 2009
  - DPOAE Normative regions for newborns
    Hunter et al., 2010



Conclusions

- Reflectance is rich in information
- It seems to be able to quantify many pathologies
- Well documented in the scientific literature
- Many new results in the last year (more on the way)

Thanks for your attention

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