Protocol for Fast, Efficient Audiogram Prediction using Electrophysiology

Sponsored By

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What Improvements Are Needed In Obtaining Audiogram Predictions in Infants??

--TESTING MUST BE FASTER TO COMPLETE AUDIOGRAM IN ONE SESSION--

1. Janssen et al (2010) found that only 80% of infants seen for audiology sleep more than 33.1 minutes. (Average is 48 minutes)
2. When testing cannot be completed, a second appointment is needed:
   - Clinics get overloaded.
   - Wait time for appointments goes up.
   - Infants get older and don't sleep as well-> sedation.
   - More infants are lost to follow up.
   - Hearing aid fittings are delayed.
3. ASSR could be faster than ABR but is not well accepted.

What Improvements Are Needed In Obtaining Audiogram Predictions in Infants??

--THRESHOLD PREDICTIONS MUST BE RELIABLE --

1. ABR testing protocols are not standardized:
   - Amount of averaging varies. Current study found that the number of sweeps needed at threshold varied from 800 to 8000.
   - Response detection is arbitrary! Varies drastically across clinics.
   - Correction factors are also unclear and arbitrary.
2. ASSR uses automated protocols that are standardize ***BUT***:
   - Many ASSR detection algorithms are not finding responses close to actual threshold.
   - Updated ASSR with better response detection is available.

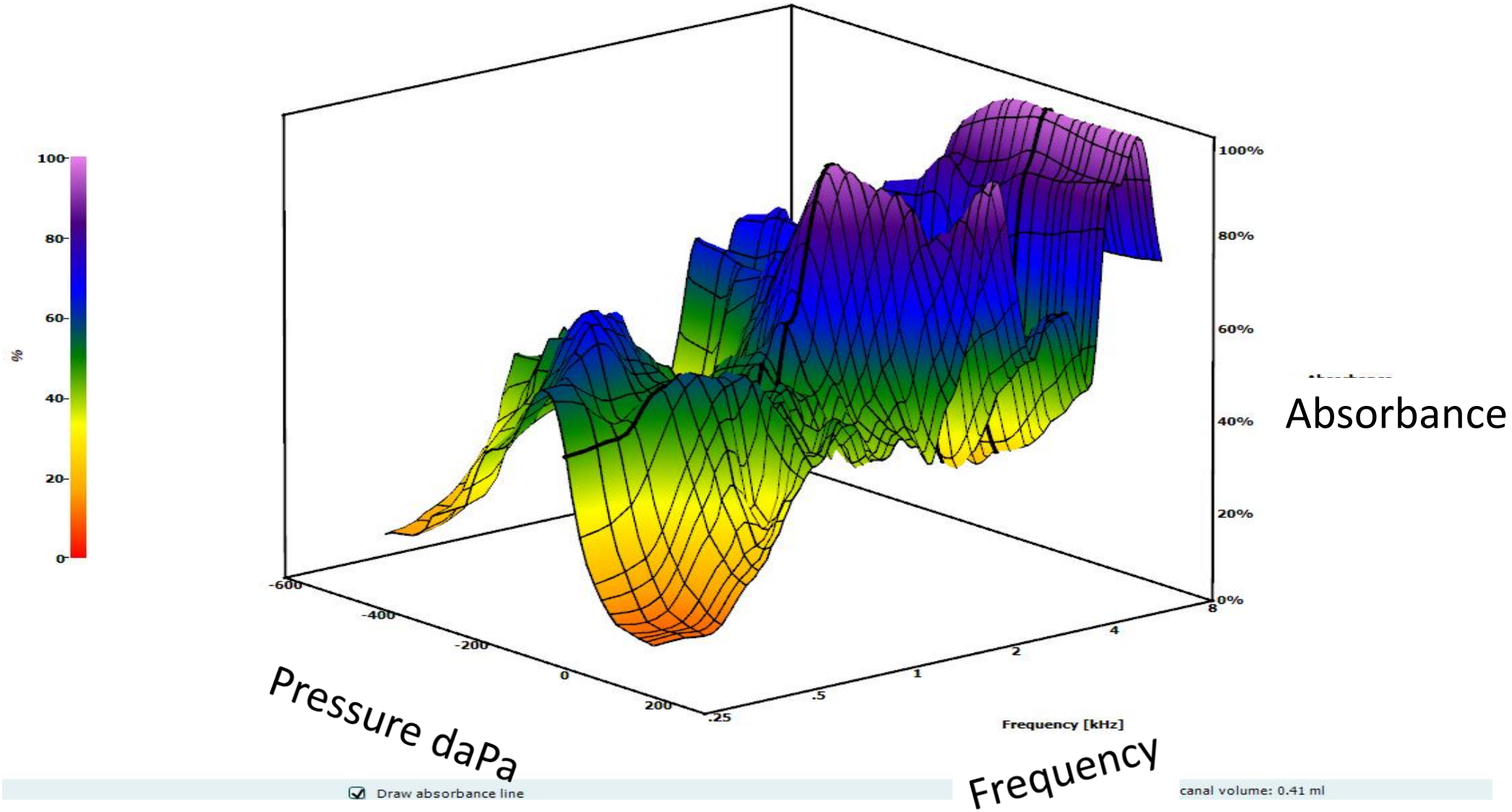
This suggested protocol is based on a recent study of 102 children.

- Start with Tympanometry and OAE
- Get an ABR threshold in each ear using a Wide-Band CE-Chirp
- Use *AUTOMATED DETECTION* for Audiogram Prediction
  - ABR thresholds using NB CE-Chirps with reliance on Fmp OR
  - ASSR thresholds using NB CE-Chirps and “Next Generation” detection protocol.
- Bone Conduction by if necessary

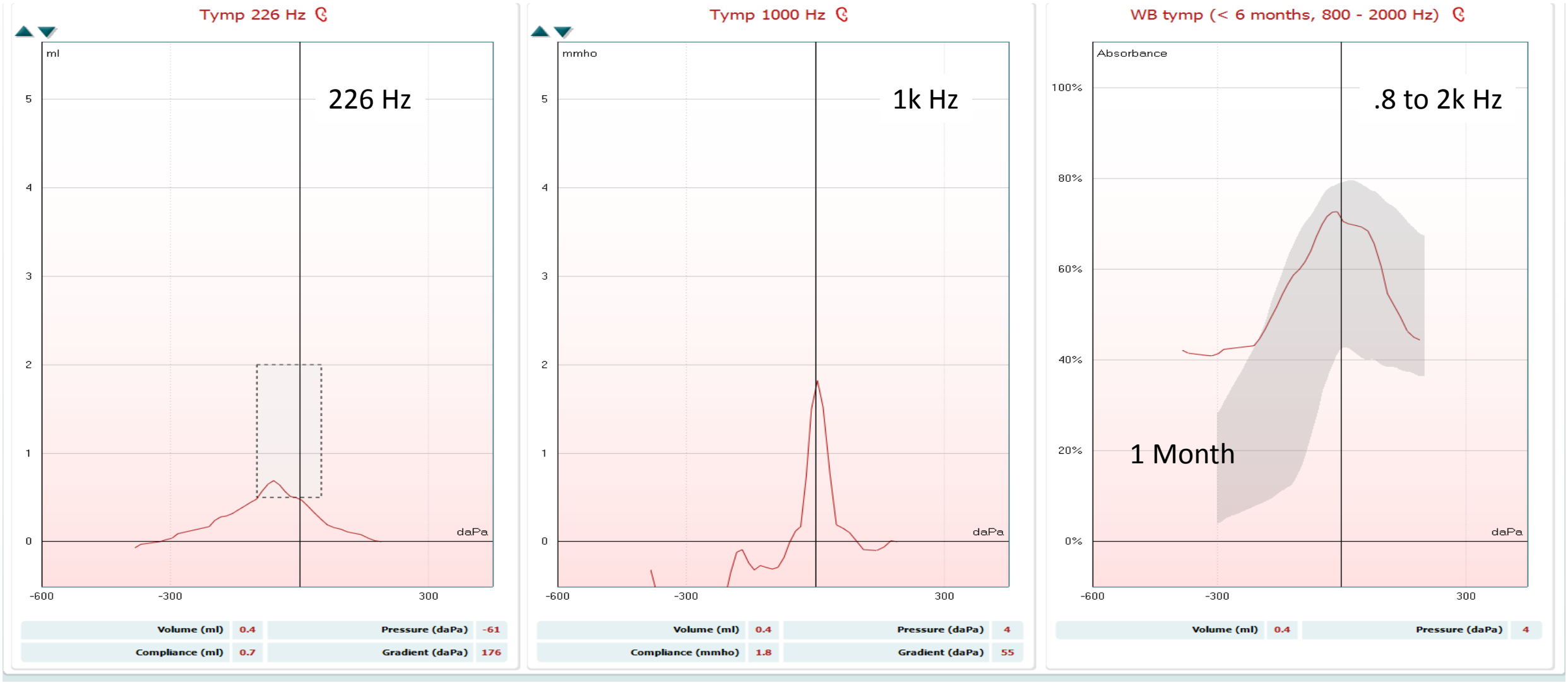
Why Start with Tympanometry and OAE?

1. Gives good advance information: Recent study, children with all points pass on DPOAE and normal Wide-Band Tympanometry had average hearing levels of 14 dB or less.
2. Easy to perform and infant does not need to be asleep
3. Knowledge of middle ear status can help guide testing decisions.
4. Advance information can help to focus the Electro-physiology and reduce test time.

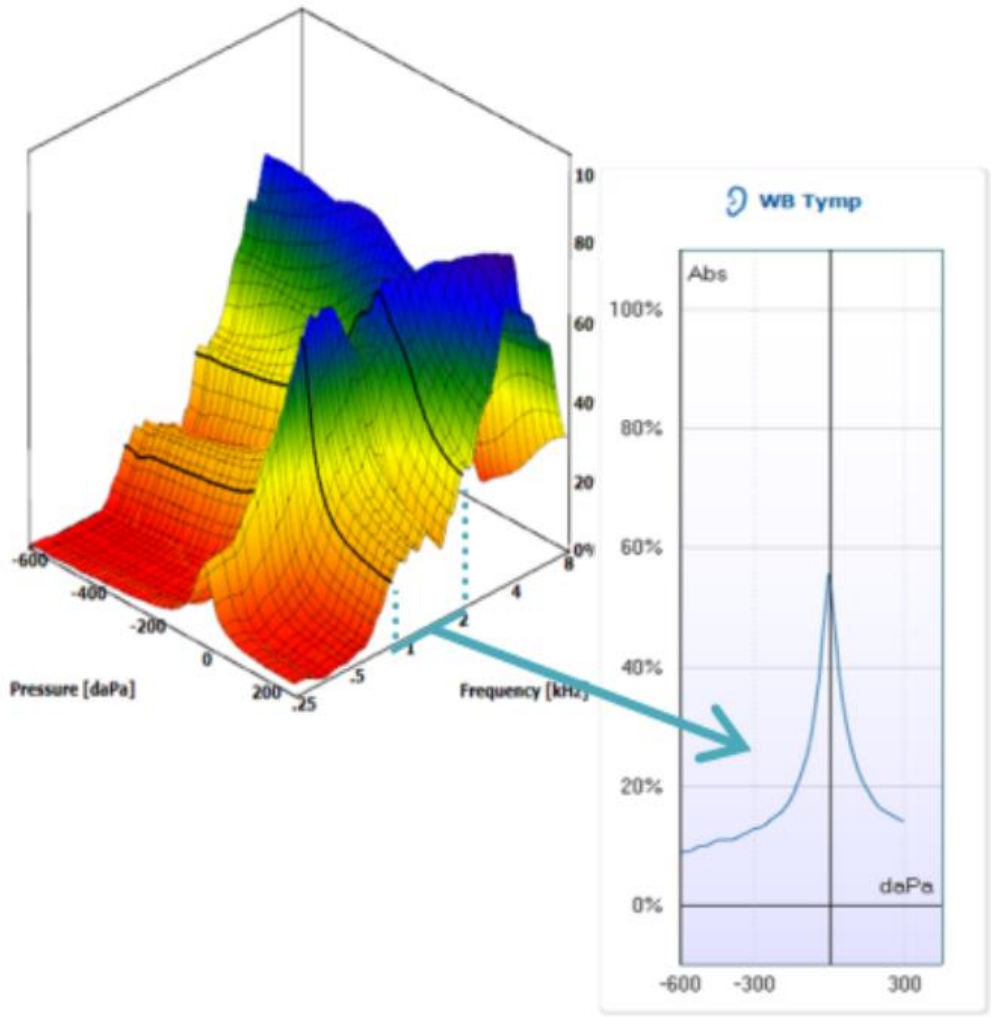
SUGGESTION: Wide Band Tympanometry



Views of individual frequency and wide-band (800-2k Hz) Tymps

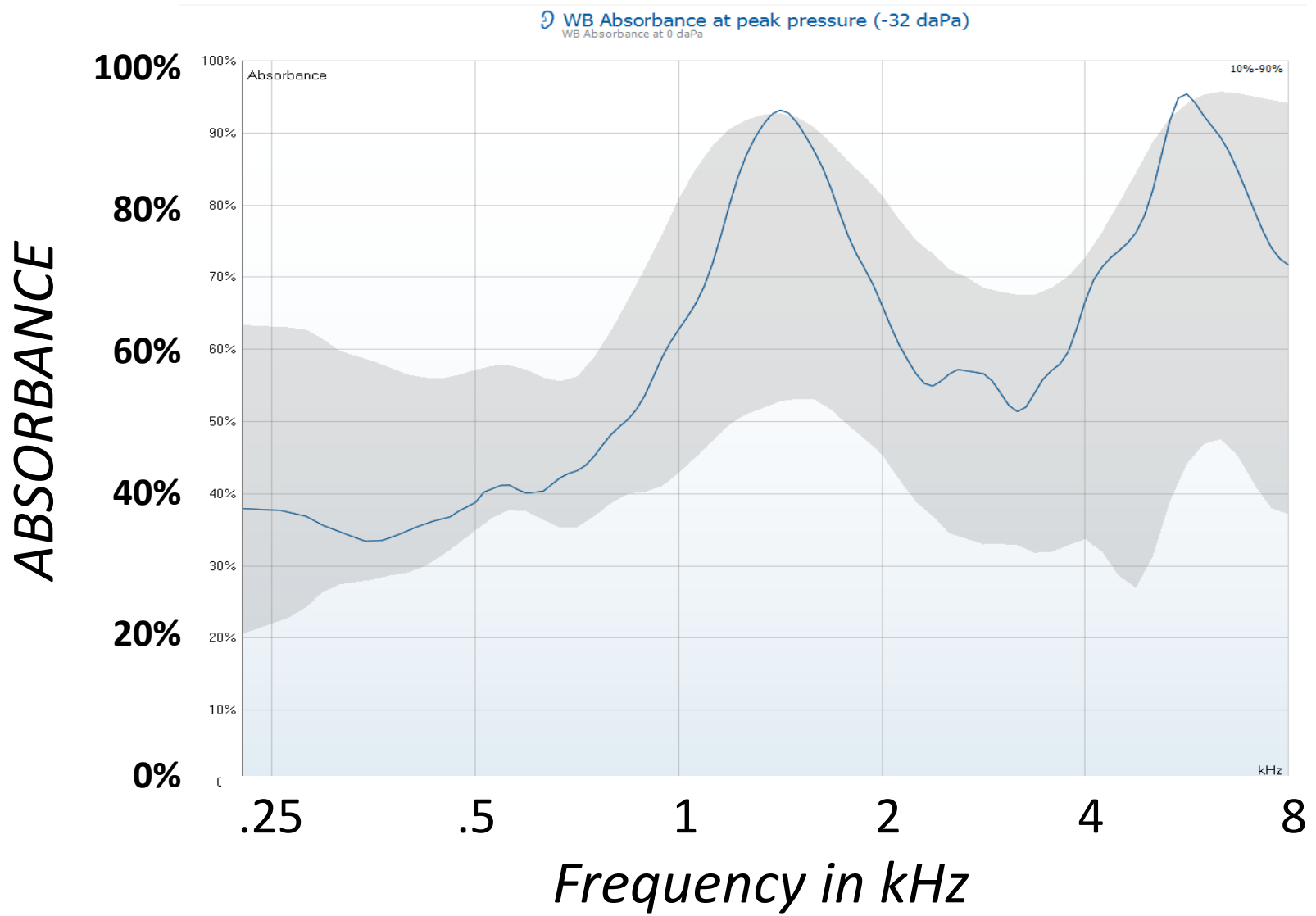


Wideband Averaged Tympanogram



For Infants < 6 months– 800-2000 Hz
For > 6 months 375- 2000 Hz

Wide Band Absorbance



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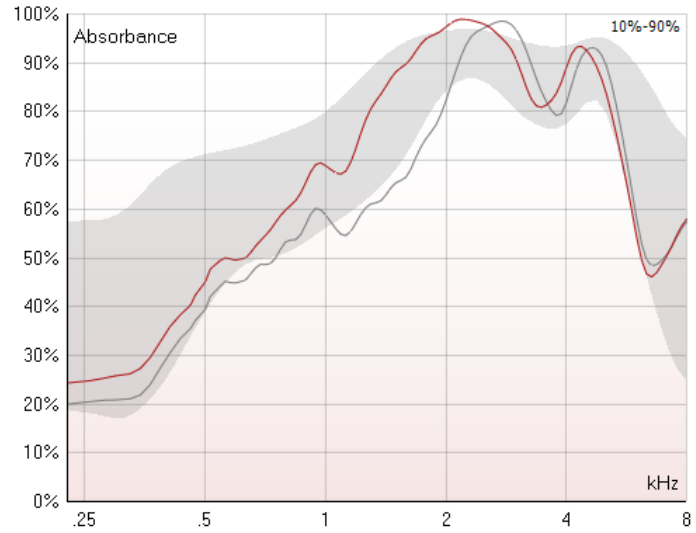
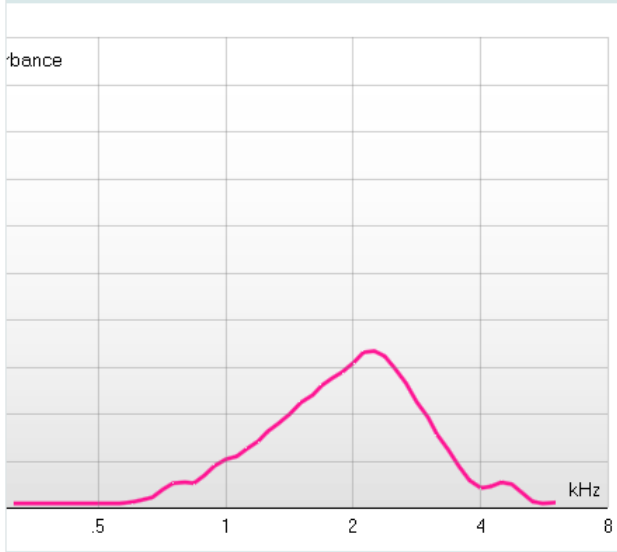
Threshold by Auditory Multiple Procedures

3D Graph | Tympanograms | Absorbances

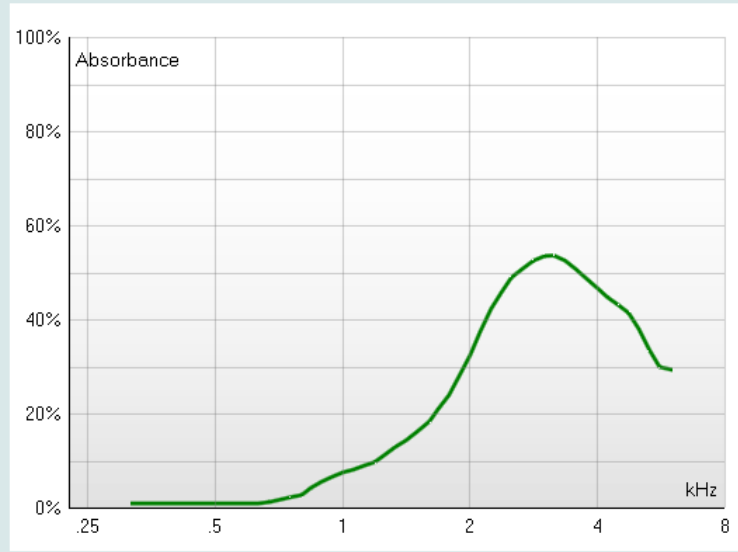
WB Absorbance at peak pressure (-106 daPa)

WB Absorbance at 0 daPa

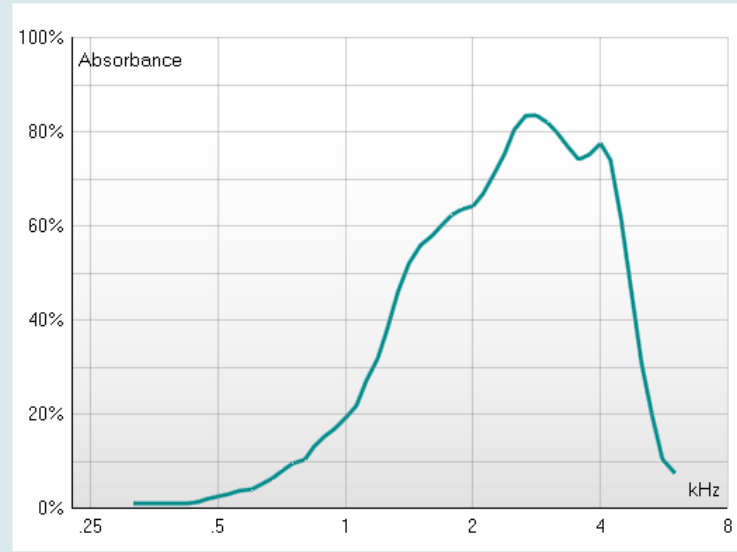




ME effusion (example)
... more info



Negative ME pressure (example)
... more info

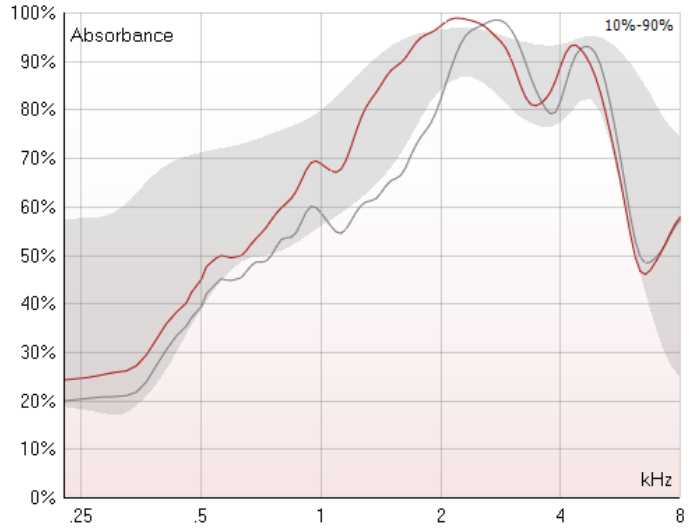


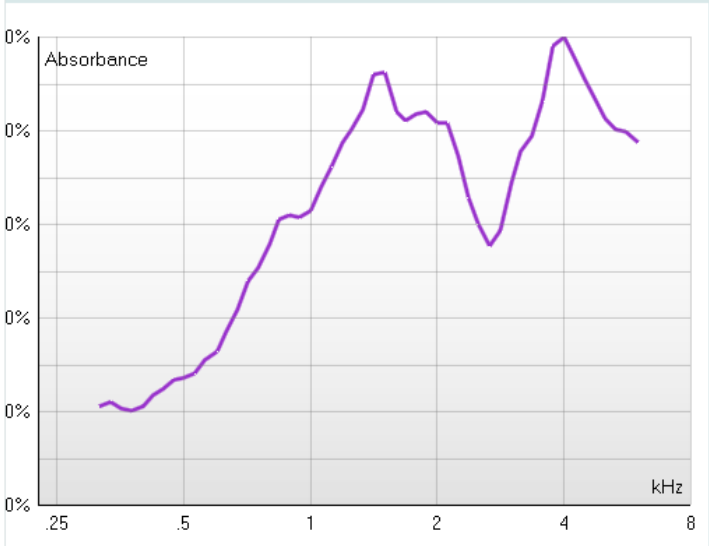
Otosclerosis (example)
... more info

3D Graph | Tympanograms | Absorbances

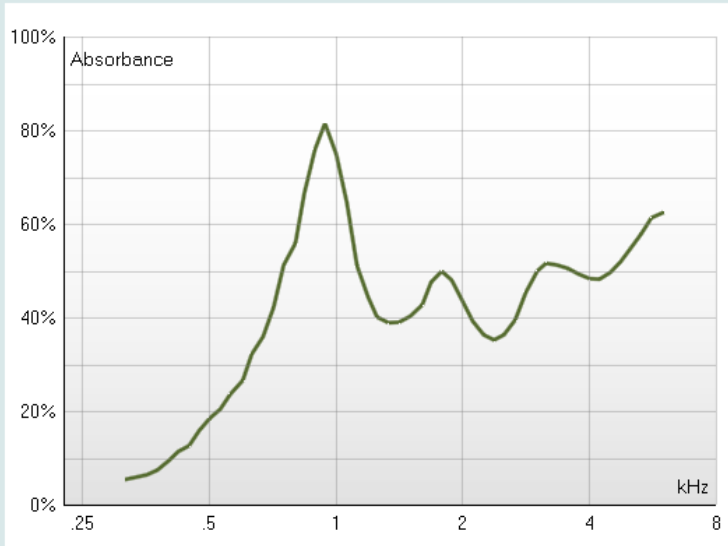
WB Absorbance at peak pressure (-106 daPa)

WB Absorbance at 0 daPa

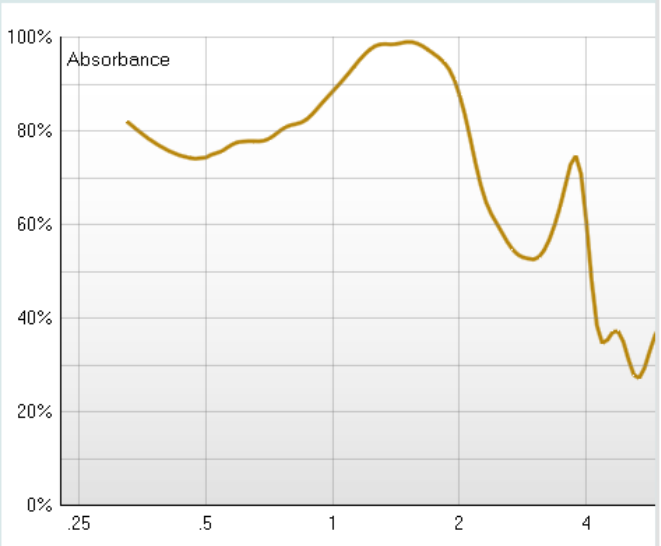




Perforation (example)
... more info



Ossicular discontinuity (example)
... more info



Loose probe fit (example)
... more info

Suggestion: Wide Band Tympanometry

- Test performed using the InterAcoustics Titan
- Medium Pump Speed
- Pressure range +200 to -400 daPa
- Both ears tested
- Click Stimuli

Same Probe Used for DPs and WB Tympanometry

Insert the probe into the ear

Good Seal

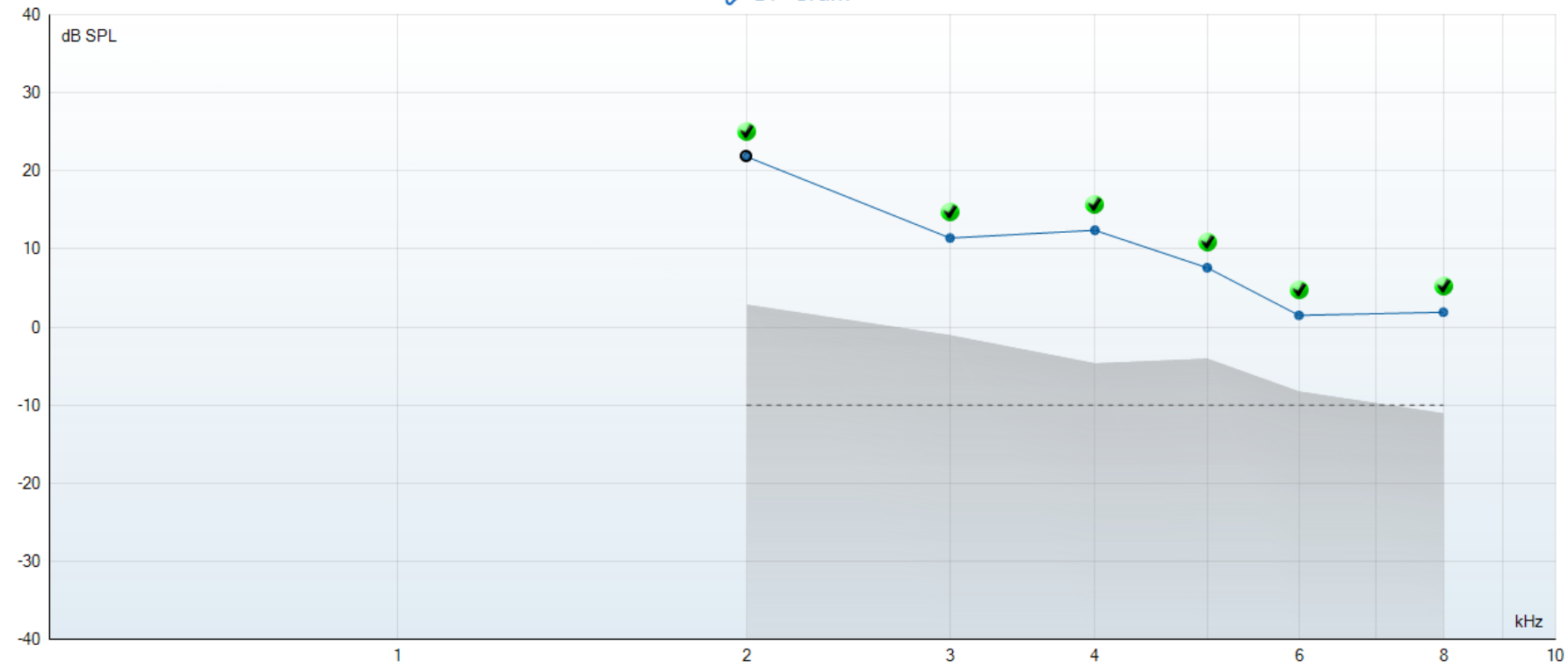
Time Saver: Insert Probe Ear 1, WB Tymp then DPOAE
Switch to Ear 2, DPOAE then WB Tymp.

SUGGESTION: DPOAEs

- Test Frequencies: 2, 3, 4, 5, 6 & 8kHz (descending order)
- f2/f1 ratio = 1.22
- L1/L2 65/55 dB SPL
- Response criteria:
  - Minimum DP Level = -10 dB SPL
  - SNR = 6 dB
  - Residual Noise = -20 dB SPL
  - DP reliability= 98%
- Not a screening protocol- Number of frequencies with DP recorded.

Response

DP-Gram



Test summary

Stimuli levels L1/L2	65/55 dB SPL
f1/f2 ratio	1.22
Min. DP reliability	98%
No. of detected points	6

Point summary

f2 (Hz)	DP level (dB SPL)	Noise (dB SPL)	SNR	Reliab. (%)	Detected
2000	21.8	2.9	18.9	99.8	✔
3000	11.4	-1.0	12.4	98.6	✔
4000	12.4	-4.6	17.0	99.9	✔
5000	7.6	-4.0	11.6	99.3	✔
6000	1.5	-8.2	9.7	98.2	✔
8000	1.9	-11.0	12.9	98.1	✔

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Threshold by Auditory Multiple Procedures

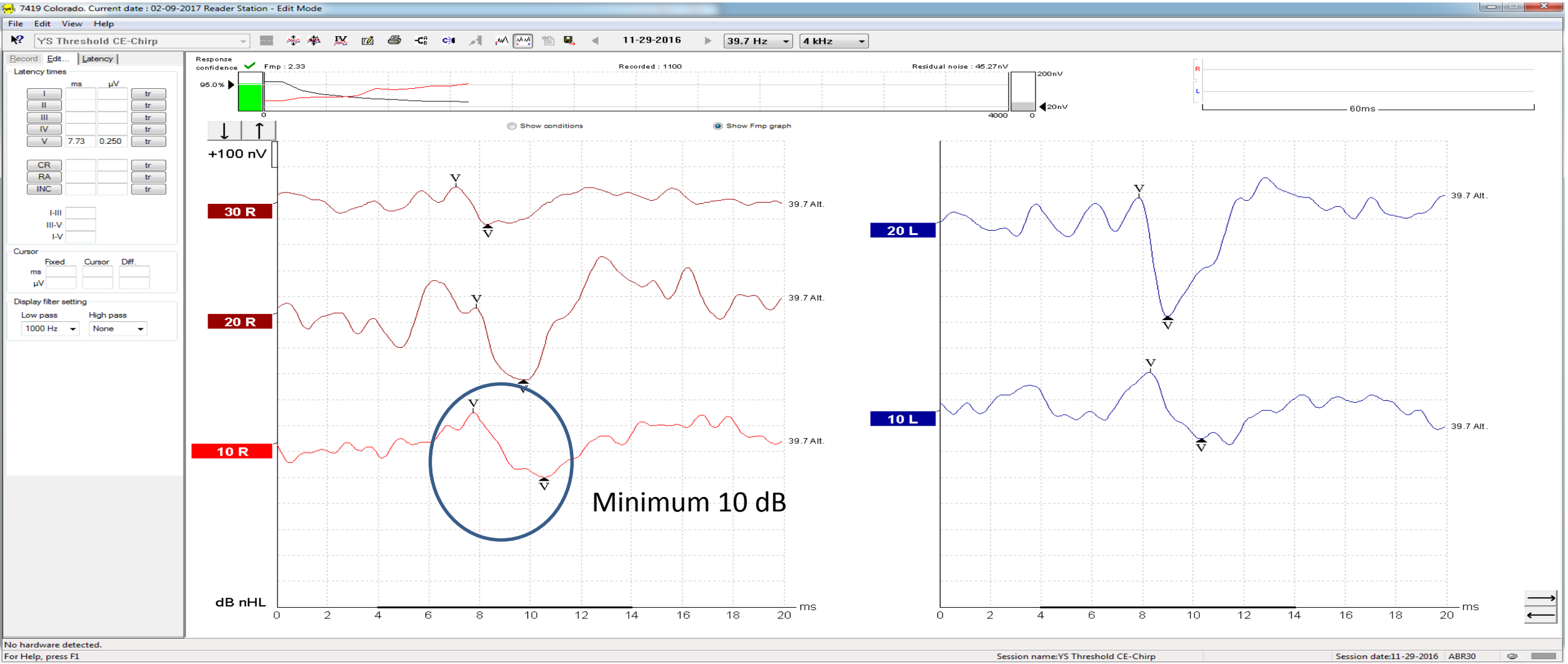
Starting with Wide-Band Tympanometry and DPOAE

Testing time for both is under 10 minutes and often less than 5 minutes for both ears.

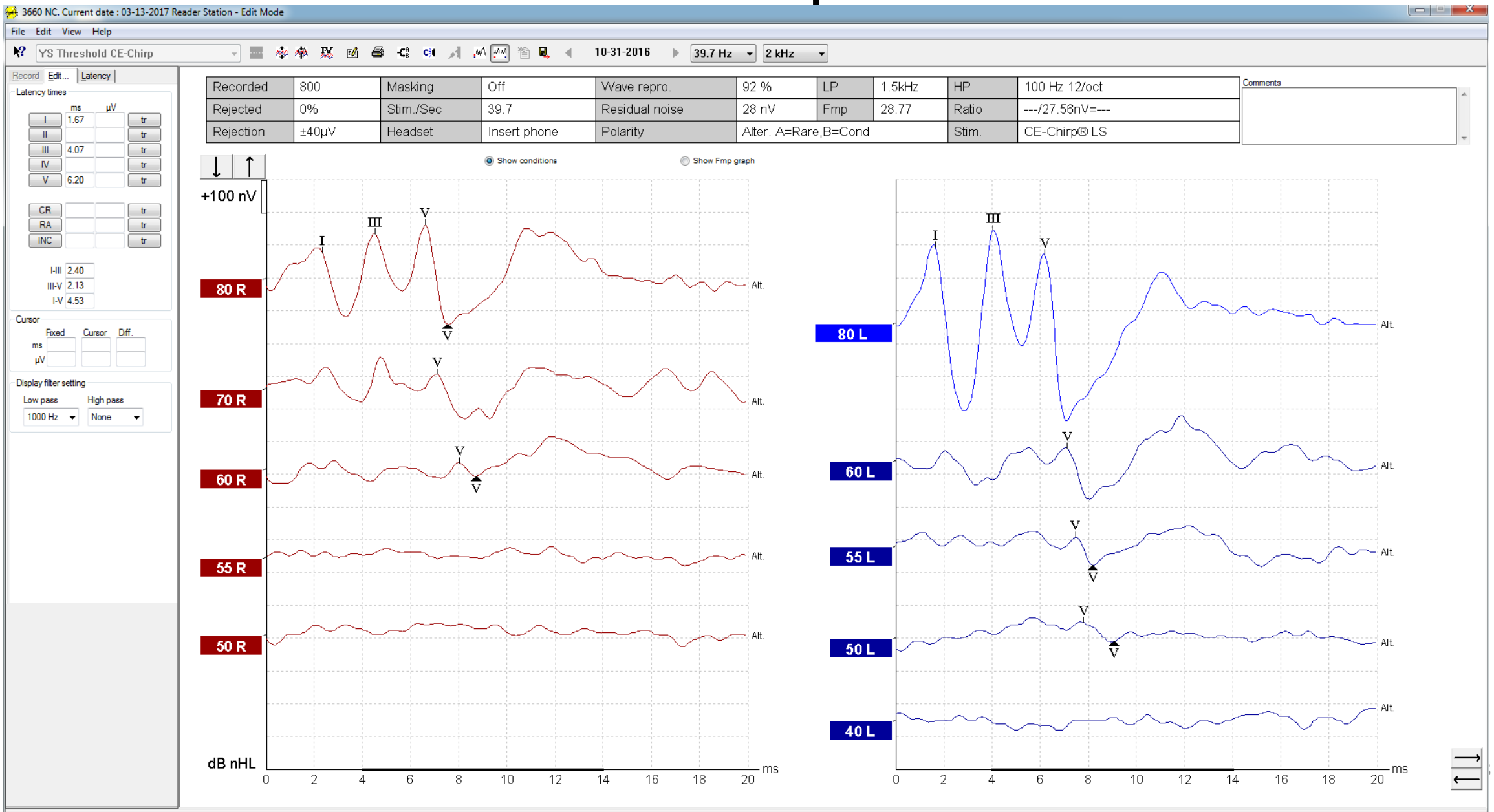
Testing after electrophysiology can wake baby who then will be fussy.

Broad-Band CE-Chirp® LS Thresholds

More advance information to streamline electrophys

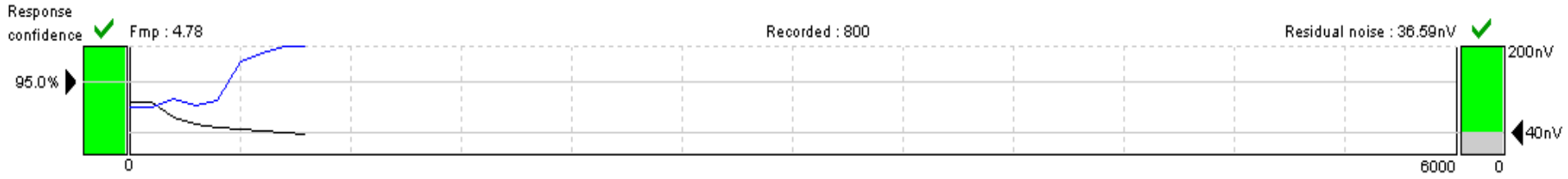


Broad-Band CE-Chirp® LS Thresholds

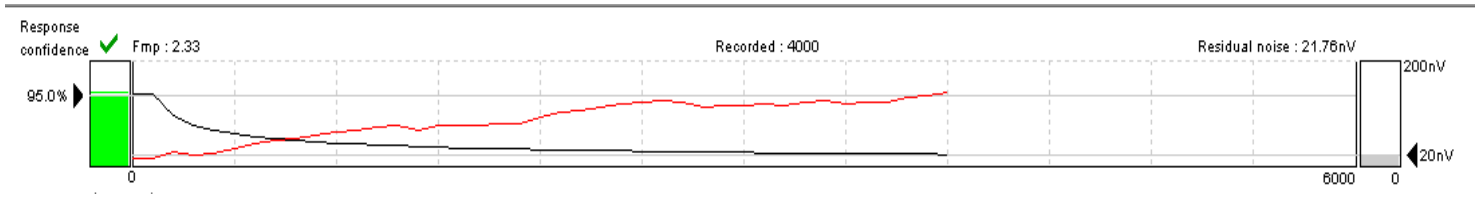


ABR Protocol-- Testing

- Use NB CE Chirps (larger amplitudes)
- Use automated detection
- Order of frequency presentation or ear is at the discretion of the tester.
- Begin the threshold search just above the BB Chirp threshold.
- Test each level ***only once*** unless special circumstances.
- If a response to level X is fast (800-1200 sweeps) and response large (>100 nV) use a large descending step size (20 or greater)



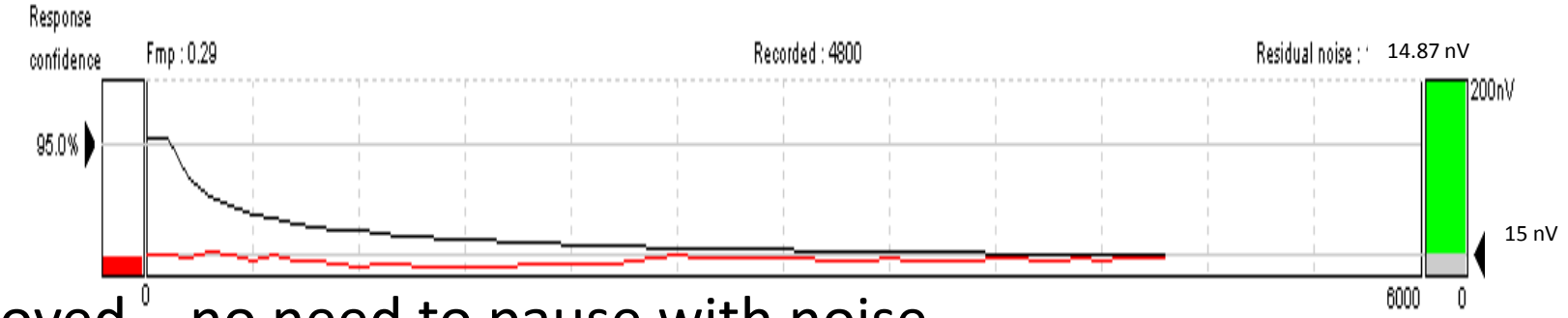
ABR Protocol-- Testing



- If response is slow (>3000 sweeps) descend in a small step size (10 dB).
- If possible use a 5 dB step size to establish threshold.
- Do not attempt to obtain thresholds below 10 dB (20 dB @ 500 Hz)
- If 5 or 6 DPOAEs are present and WB CE-Chirp threshold is 10-15 dB, start testing NB Chirps at 20 or 10 dB.
- Do everything possible to complete the test as quickly as possible:
  - Do not repeat responses that meet criteria unless necessary
  - do not test more levels than necessary
  - start threshold search at or near BB CE-Chirp threshold
  - do not stop to mark responses until after the test is fully completed

ABR Protocol--Setup

- Stimuli: .5, 1, 2, & 4kHz NB CE-Chirps LS (nHL calibration)
  - Alternating Polarity
  - 39.7/ second
  - ER-3 Insert Earphones
- Filters: 100-1500 Hz
- Window: 0-20 ms
- Stopping Rule: Which ever happens first-
  - Fmp = 2.25 (95%)
  - Residual Noise = 15 nV
  - Sweeps = 6000
- Bayesian Weighting employed – no need to pause with noise.



3660 NC. Current date : 03-13-2017 Reader Station - Edit Mode

File Edit View Help

YS 2kHz CE-Chirp | 10-31-2016 | 39.7 Hz | 2 kHz

Record | Edit... | Latency

Latency times

	ms	µV	
I			tr
II			tr
III			tr
IV			tr
V			tr
CR			tr
RA			tr
INC			tr

I-III
III-V
I-V

Cursor

	Fixed	Cursor	Diff.
ms			
µV			

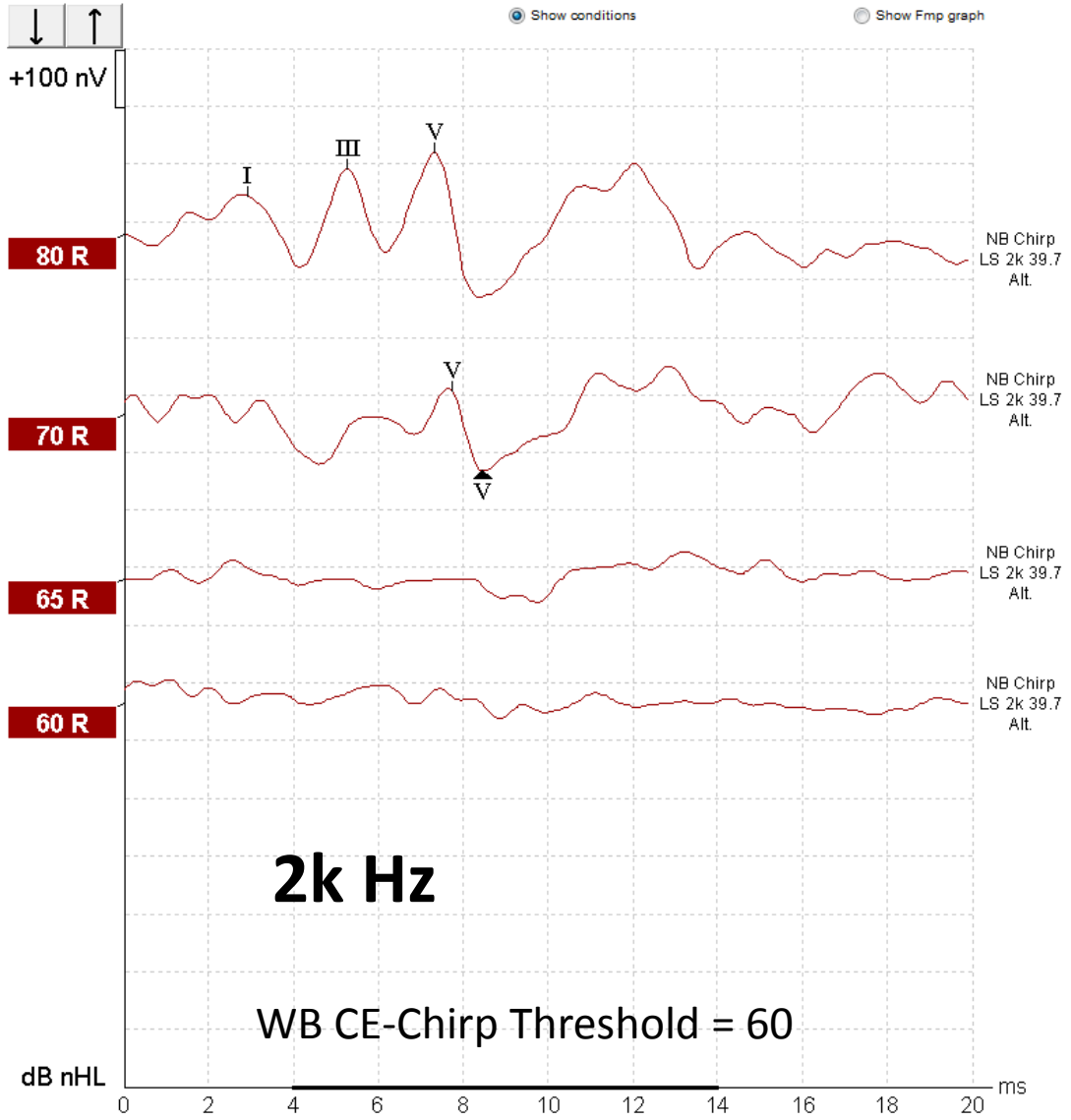
Display filter setting

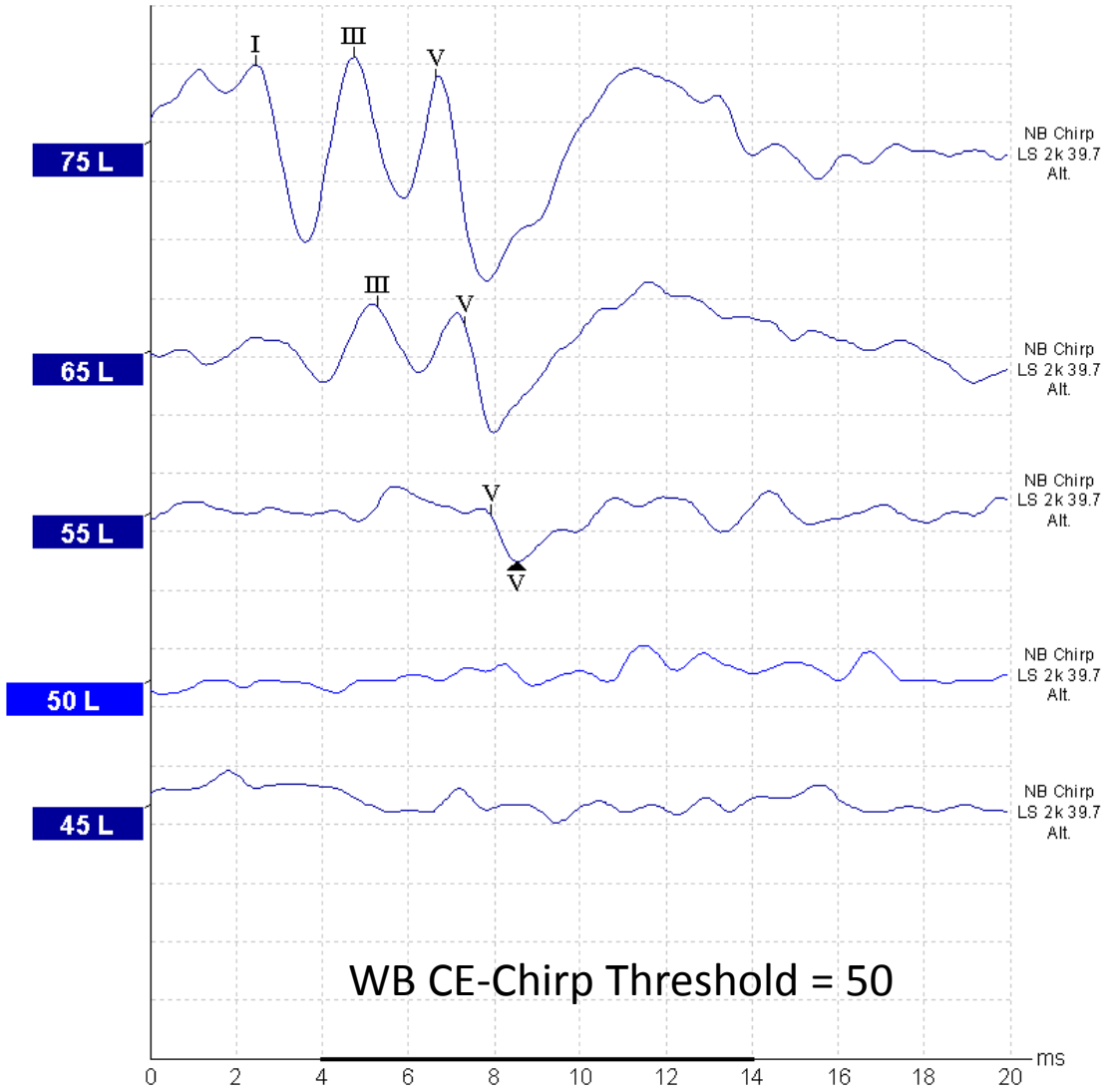
Low pass: 1000 Hz | High pass: None

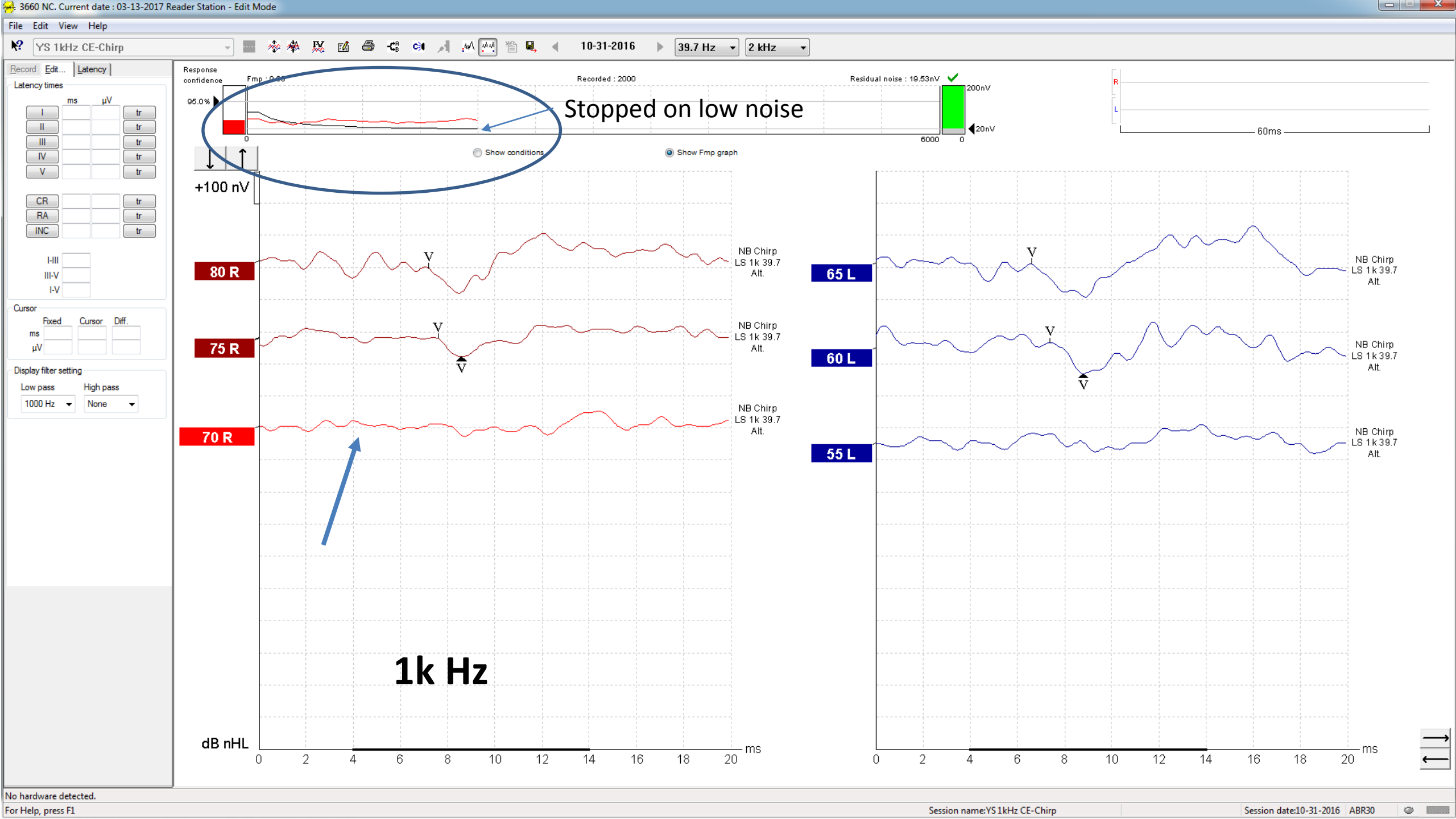
Recorded	1500	Masking	Off	Wave repro.	17 %	LP	1.5kHz	HP	100 Hz 12/oct
Rejected	0%	Stim./Sec	39.7	Residual noise	20 nV	Fmp	1.22	Ratio	---/19.82nV=---
Rejection	±39µV	Headset	Insert phone	Polarity	Alter. A=Rare,B=Cond			Stim.	NB CE-Chirp® LS,2k

Comments

Show conditions | Show Fmp graph






3660 NC. Current date : 03-13-2017 Reader Station - Edit Mode
File Edit View Help
YS 1kHz CE-Chirp
10-31-2016
39.7 Hz
2 kHz
Record Edit... Latency
Latency times
ms µV
I II III IV V CR RA INC
tr
I-III III-V I-V
Cursor
Fixed Cursor Diff.
ms µV
Display filter setting
Low pass High pass
1000 Hz None
Response confidence
95.0%
Fmp : 0.00
Recorded : 2000
Residual noise : 19.53nV
200nV
20nV
6000
Stopped on low noise
Show conditions
Show Fmp graph
R
L
60ms
+100 nV
80 R
75 R
70 R
NB Chirp LS 1k 39.7 Alt.
V
1k Hz
dB nHL
ms
0 2 4 6 8 10 12 14 16 18 20
65 L
60 L
55 L
No hardware detected.
For Help, press F1
Session name:YS 1kHz CE-Chirp
Session date:10-31-2016
ABR30

Special Circumstances

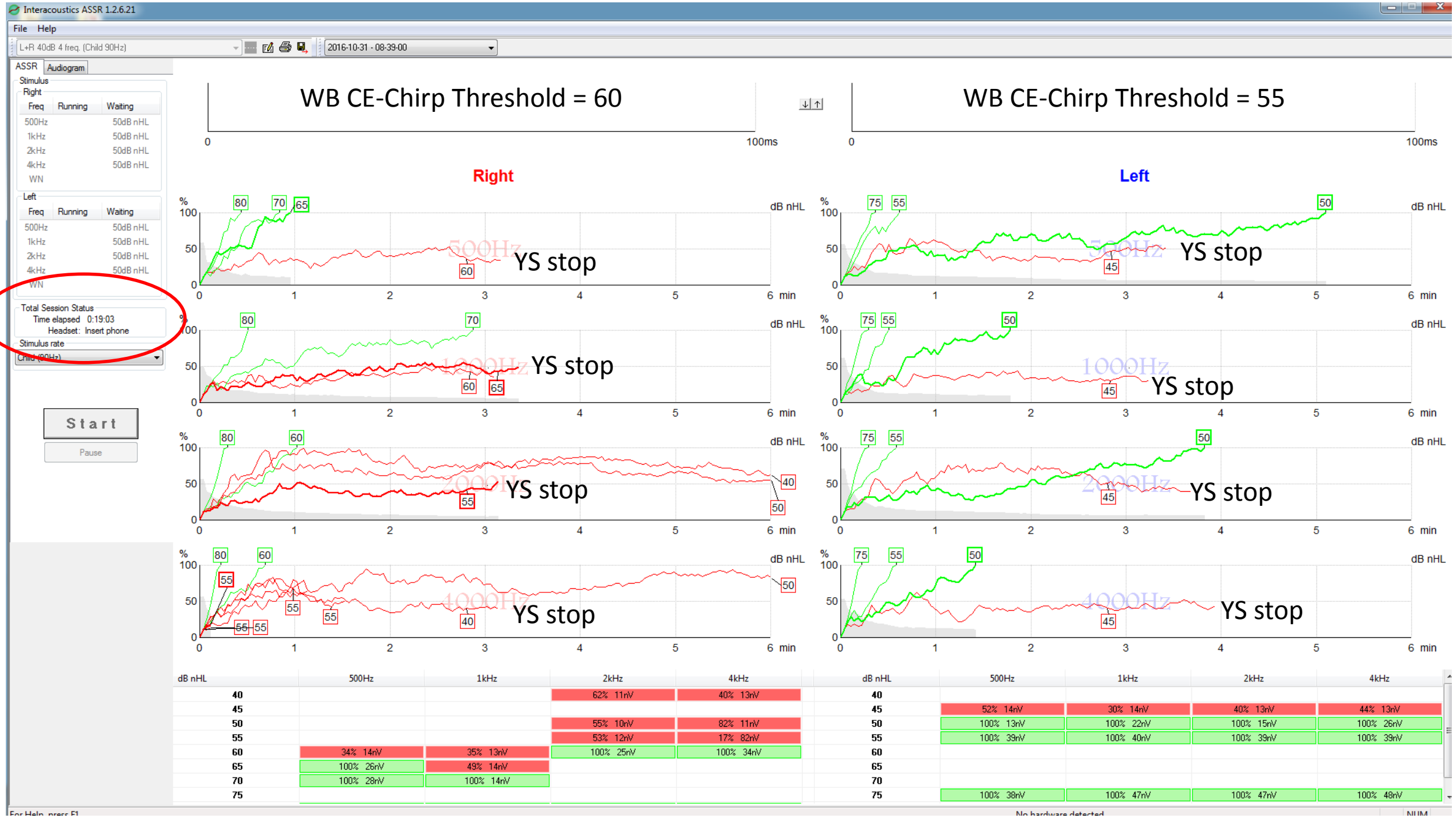
- If Fmp is growing but may not reach in 6000 sweeps, additional number of sweeps can be added by the user.
- Before using external isolation transformers, noise interfered with Fmp detection in three cases where exceptional noise interference was detected.

ASSR Protocol

- Default is 4 frequencies per ear all running simultaneously.
- Starting Level is determined by tester, start 10-20 dB above WB CE-Chirp threshold.
- Each frequency has a unique modulation frequency that is close to 90 Hz.
- Background noise and response detection criteria are automatically updated for each frequency/ear.
- New stimulus level can be implemented for any of the eight conditions at any time. The others continue to run.

ASSR Protocol

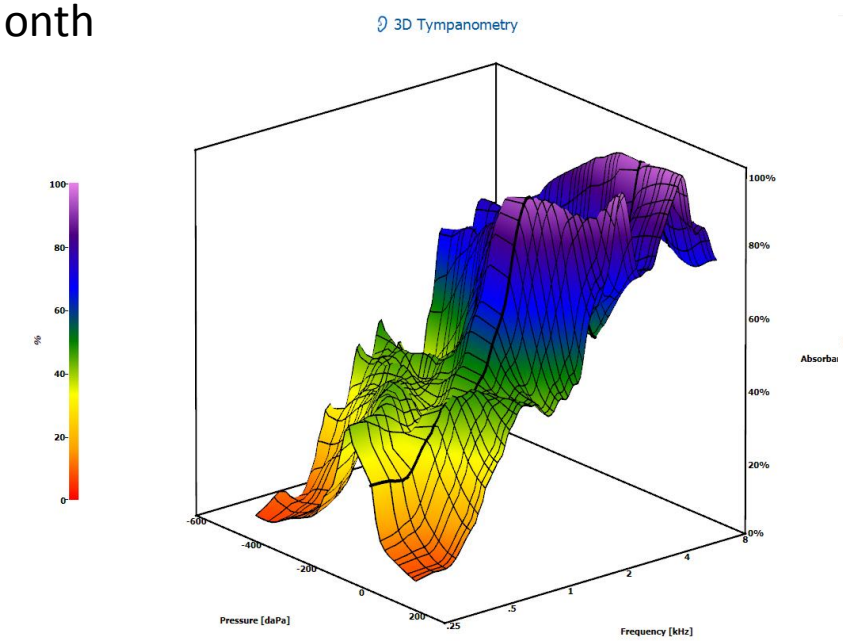
- Noise rejection level is set to 40 nV.
- Insert ER3-A Earphones used.
- Test will stop at 95% confidence of response or 6 minutes.
- Test time can be extended for any particular condition if needed.
- YS stopping rule. If detection is at or below 50% and noise is <= 15 nV, the test can be stopped by the user as a no response.
- Test levels are determined as with ABR with concentration on test speed. A response met quickly warrants a large decrease in level and vice versa.

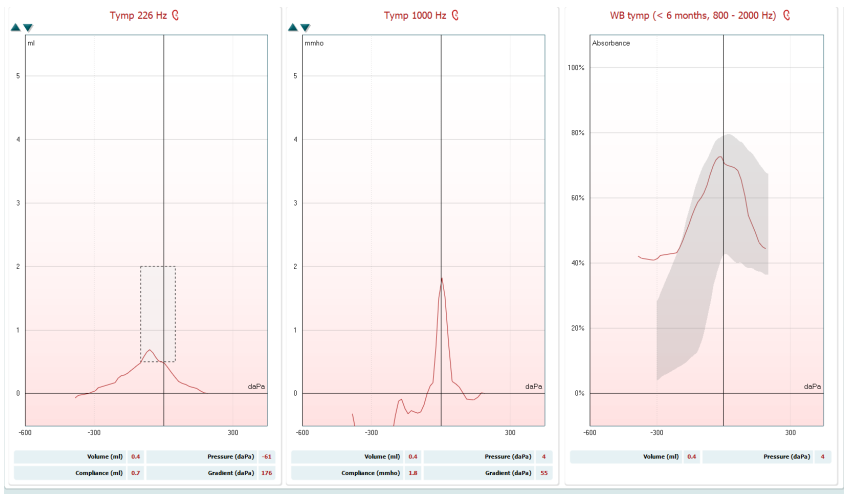

Interacoustics ASSR 1.2.6.21
File Help
L+R 40dB 4 freq. (Child 90Hz)
2016-10-31 - 08-39-00
ASSR
Audiogram
Stimulus
Right
Freq Running Waiting
500Hz 50dB nHL
1kHz 50dB nHL
2kHz 50dB nHL
4kHz 50dB nHL
WN
Left
Freq Running Waiting
500Hz 50dB nHL
1kHz 50dB nHL
2kHz 50dB nHL
4kHz 50dB nHL
WN
Total Session Status
Time elapsed 0:19:03
Headset: Insert phone
Stimulus rate
Child (90Hz)
Start
Pause
WB CE-Chirp Threshold = 60
0
100ms
WB CE-Chirp Threshold = 55
0
100ms
Right
Left
% 100 50 0
dB nHL
0 1 2 3 4 5 6 min
80 70 65
500Hz
60
YS stop
75 55 50
500Hz
45
YS stop
80 70
1000Hz
60 65
YS stop
75 55 50
1000Hz
45
YS stop
80 60
2000Hz
55 40 50
YS stop
75 55 50
2000Hz
45
YS stop
80 60 55 55 55 55 55
4000Hz
40 50
YS stop
75 55 50
4000Hz
45
YS stop
dB nHL 500Hz 1kHz 2kHz 4kHz
40 62% 11nV 40% 13nV
45
50 55% 10nV 82% 11nV
55 53% 12nV 17% 82nV
60 34% 14nV 35% 13nV 100% 25nV 100% 34nV
65 100% 26nV 49% 14nV
70 100% 28nV 100% 14nV
75
dB nHL 500Hz 1kHz 2kHz 4kHz
40
45 52% 14nV 30% 14nV 40% 13nV 44% 13nV
50 100% 13nV 100% 22nV 100% 15nV 100% 26nV
55 100% 39nV 100% 40nV 100% 39nV 100% 39nV
60
65
70
75 100% 38nV 100% 47nV 100% 47nV 100% 48nV

1 month old
Natural Sleep
Failed NHS- no other risks
Subject 6514 1 Month

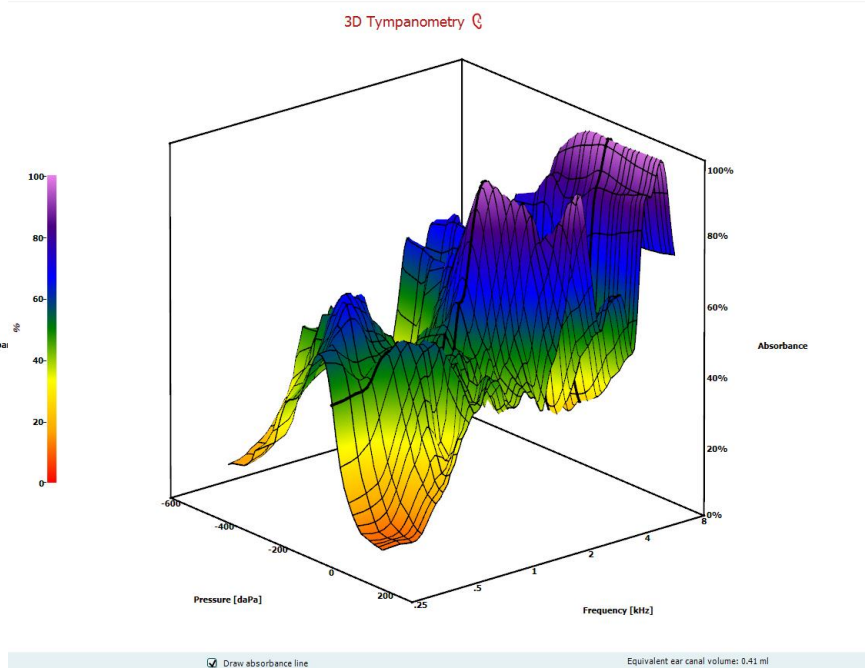
Broad Band Tympanometry

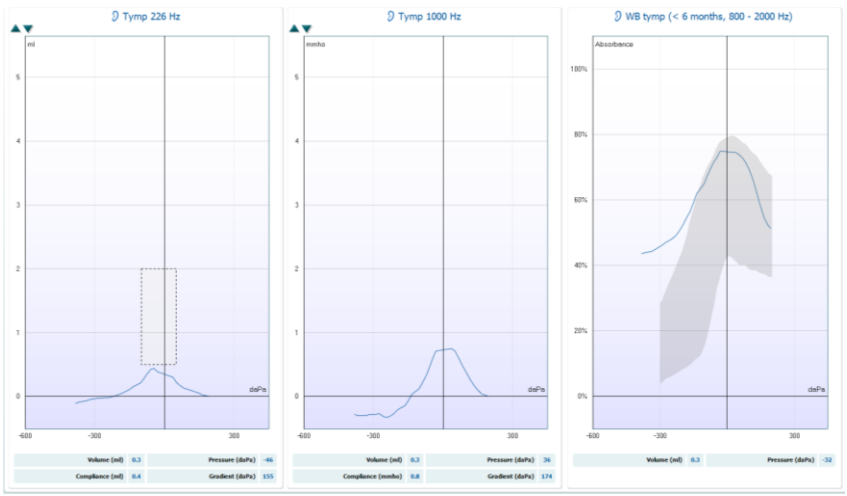
Left Ear





Right Ear

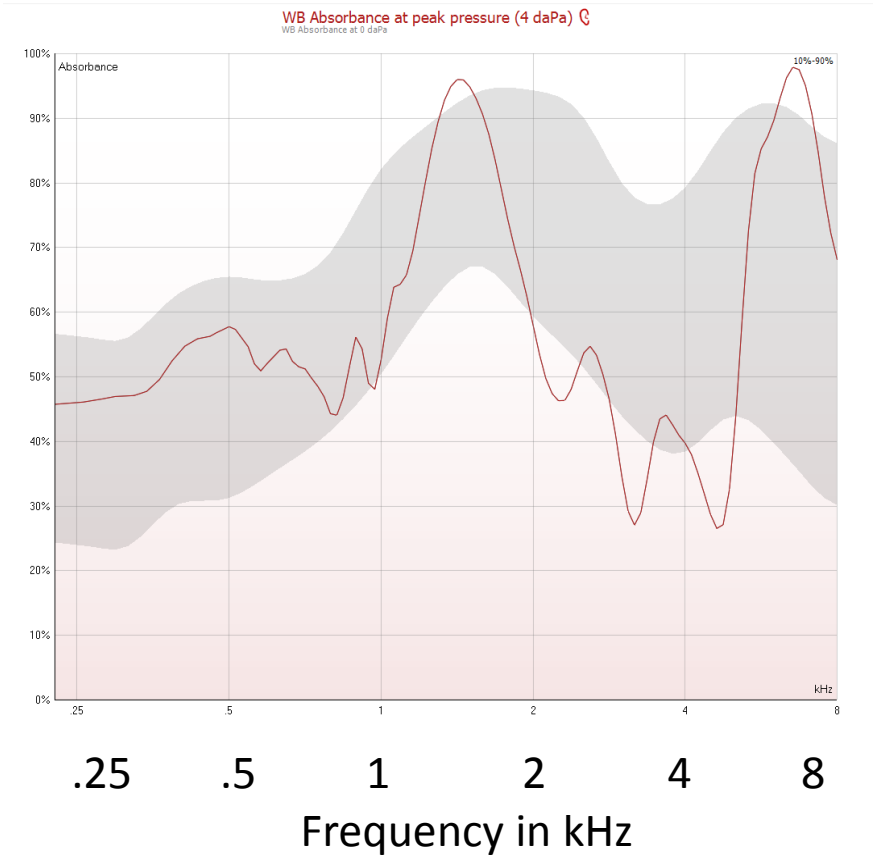




Subject 6514 1 Month

Wide Band Absorbance

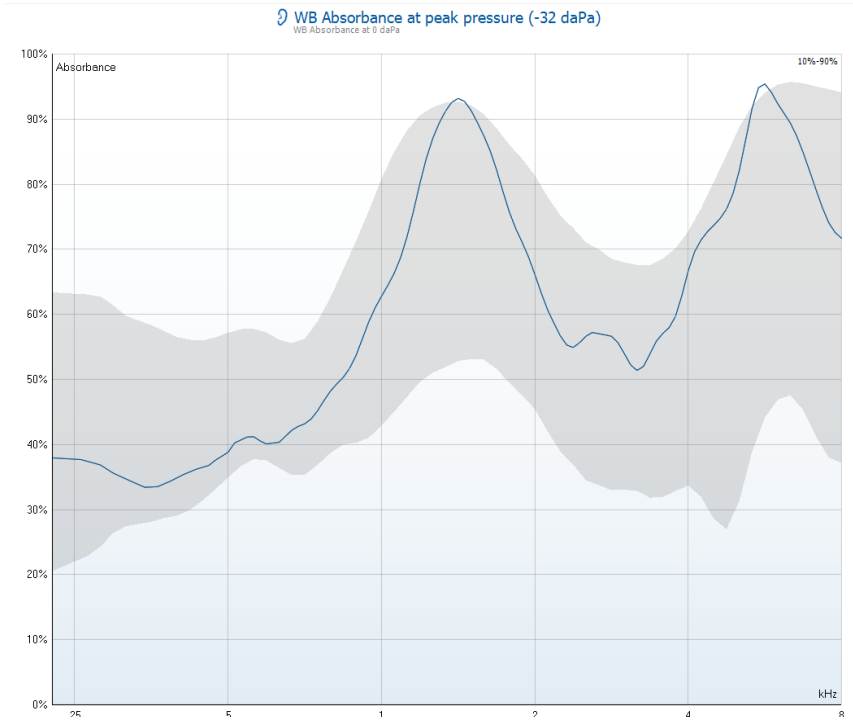
Right Ear



.25 .5 1 2 4 8

Frequency in kHz

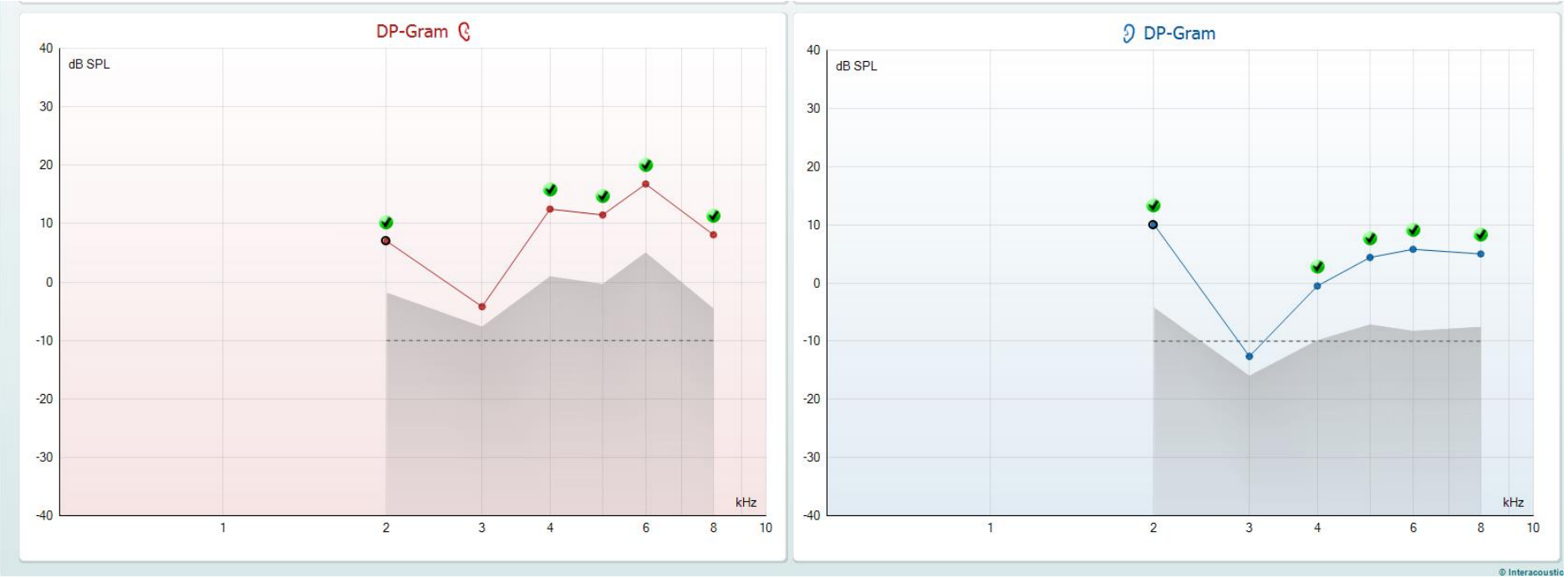
Left Ear



.25 .5 1 2 4 8

Frequency in kHz

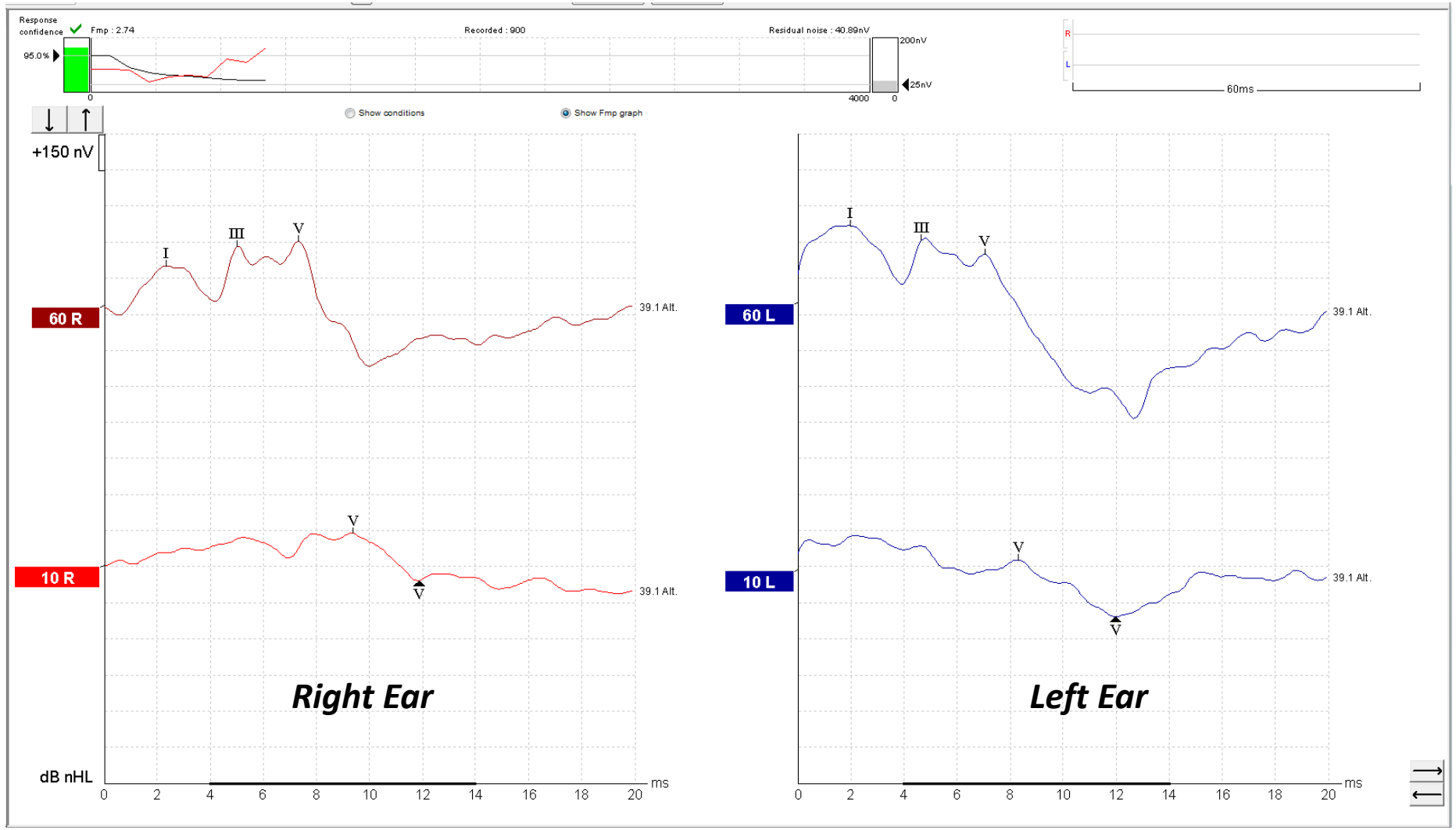
DPOAEs



Right Ear ***Left Ear***

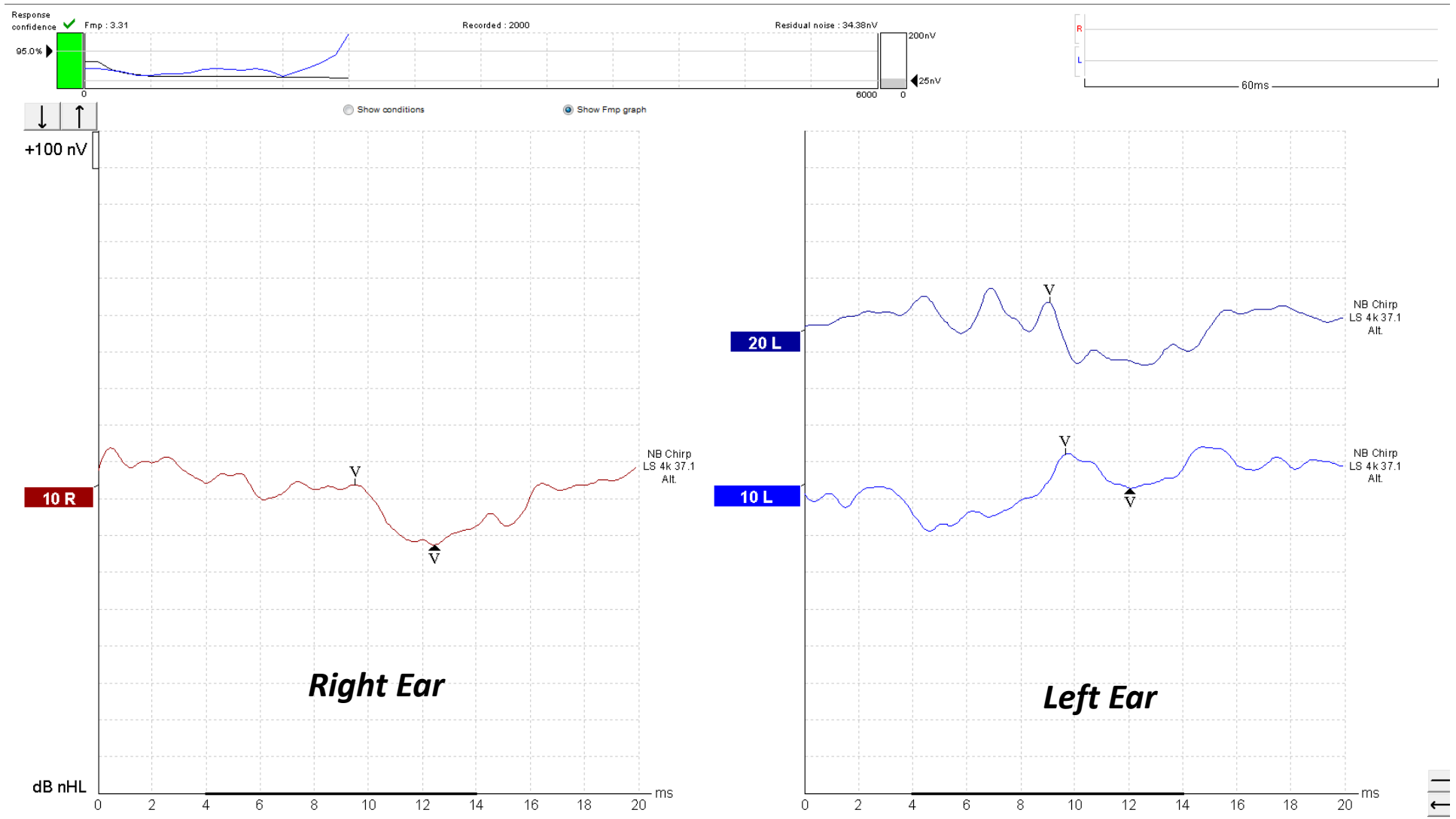
Subject 6514 1 Month

Broad Band CE-Chirp ABR Threshold
<10 dB Both Ears



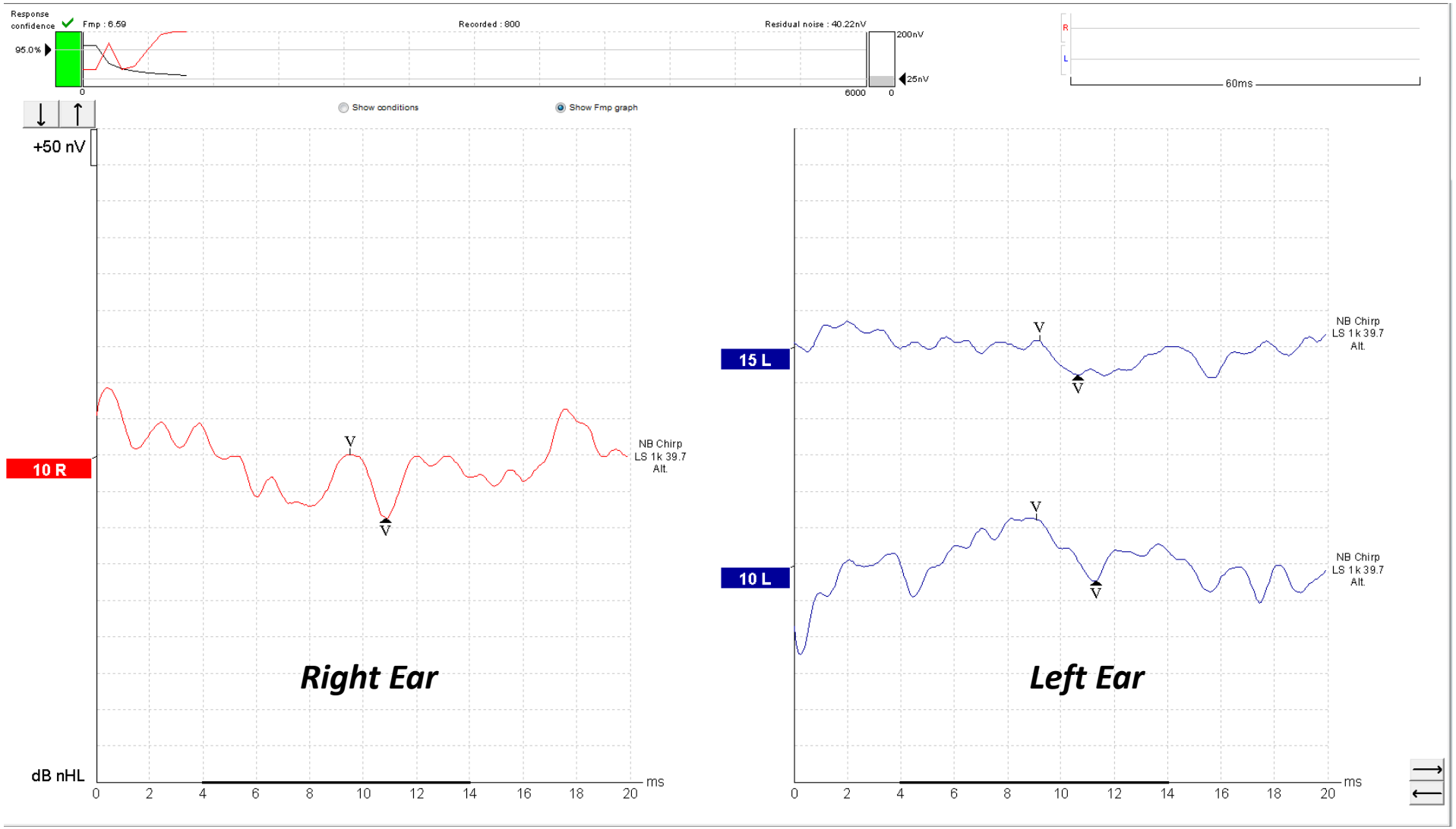
Subject 6514 1 Month

4k Hz <10 dB Both Ears



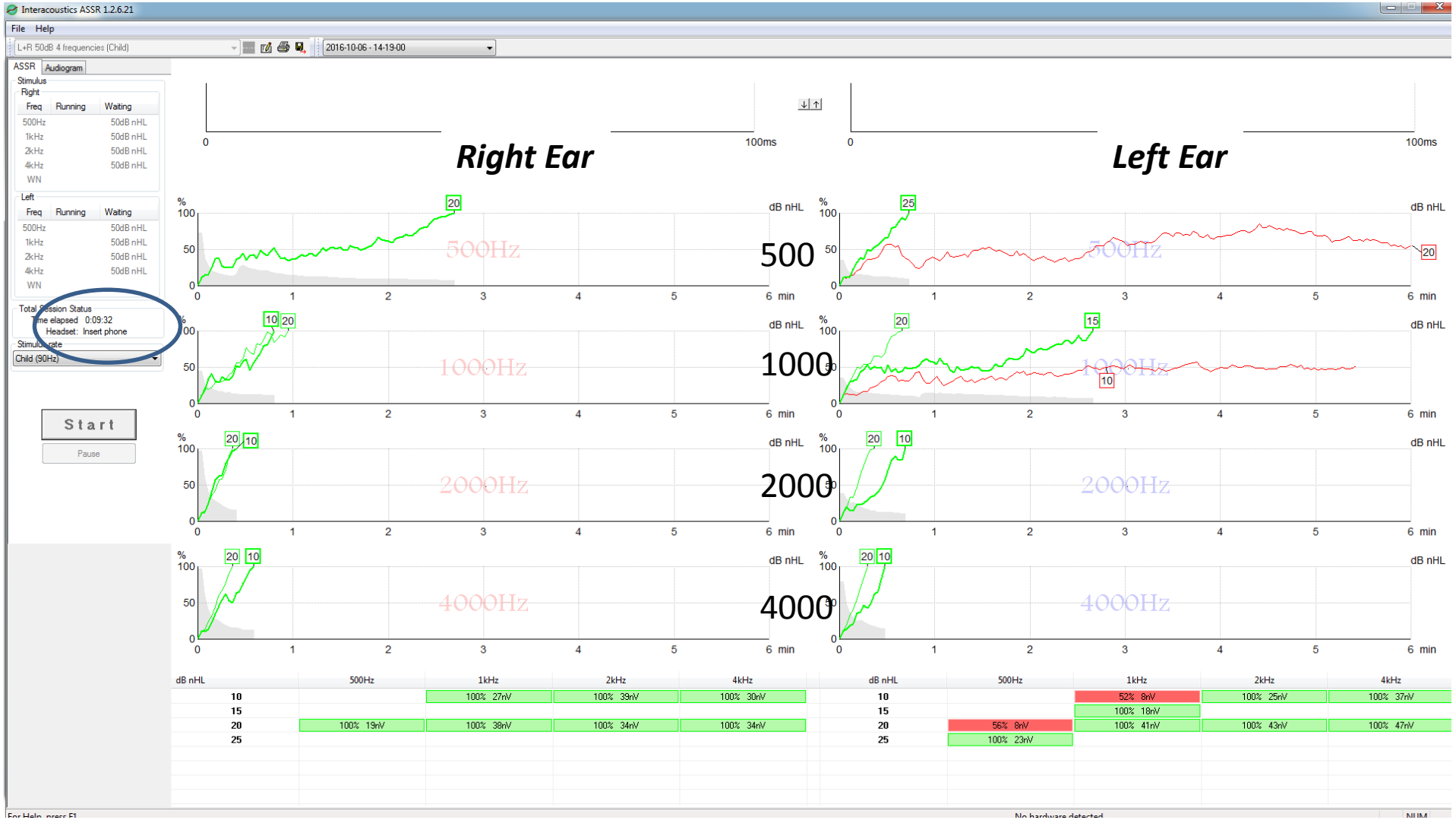
Subject 6514 1 Month

1k Hz < 10 dB Both Ears



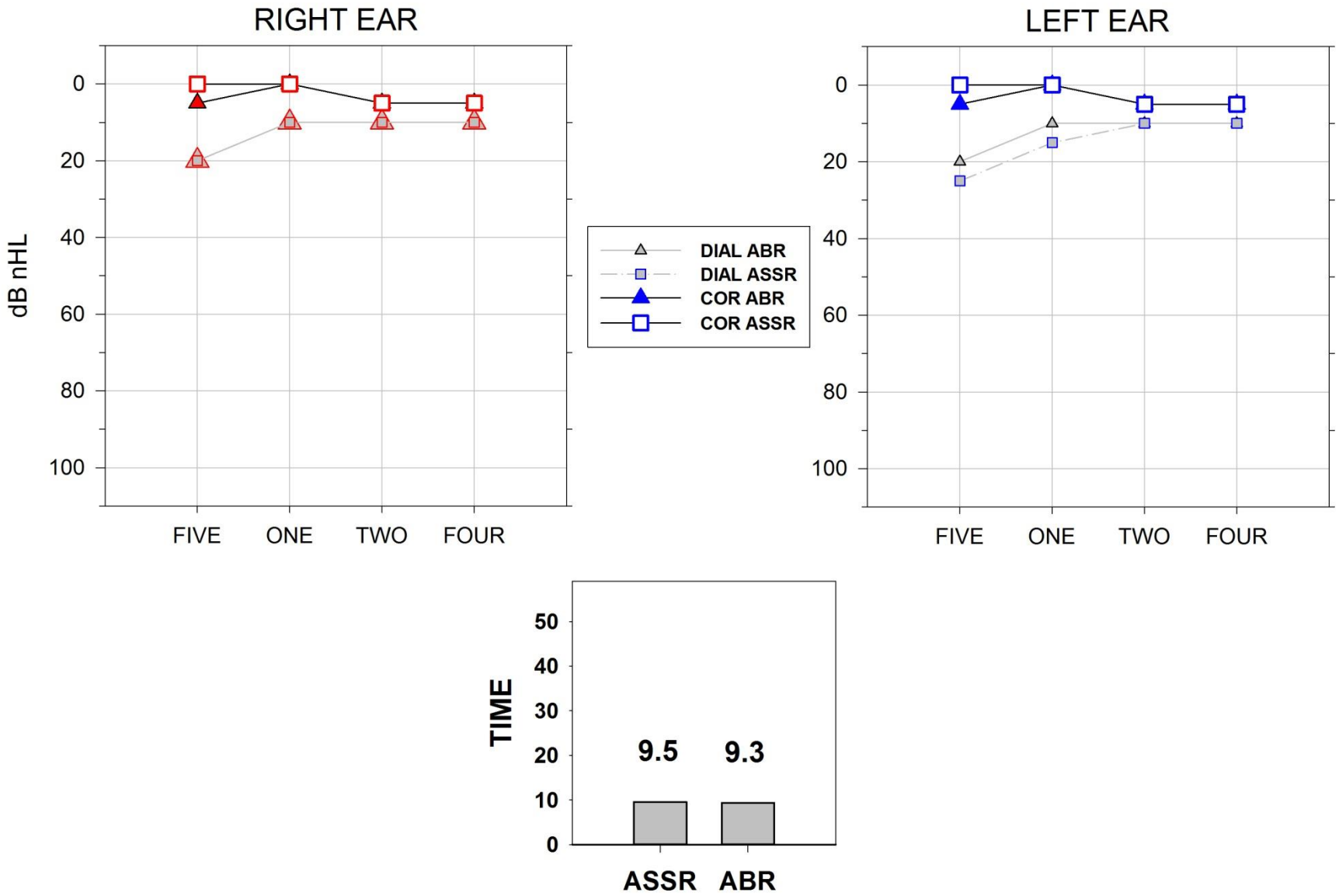
Subject 6514 1 Month

ASSR



Subject 6514 1 Month

6514 1 Month - Natural Sleep - Failed Screening



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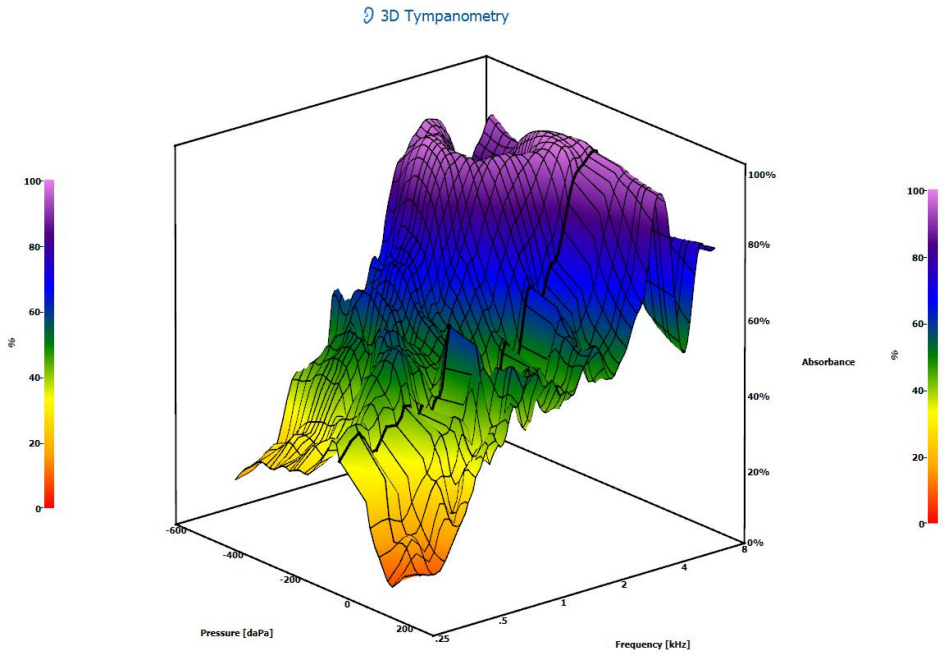
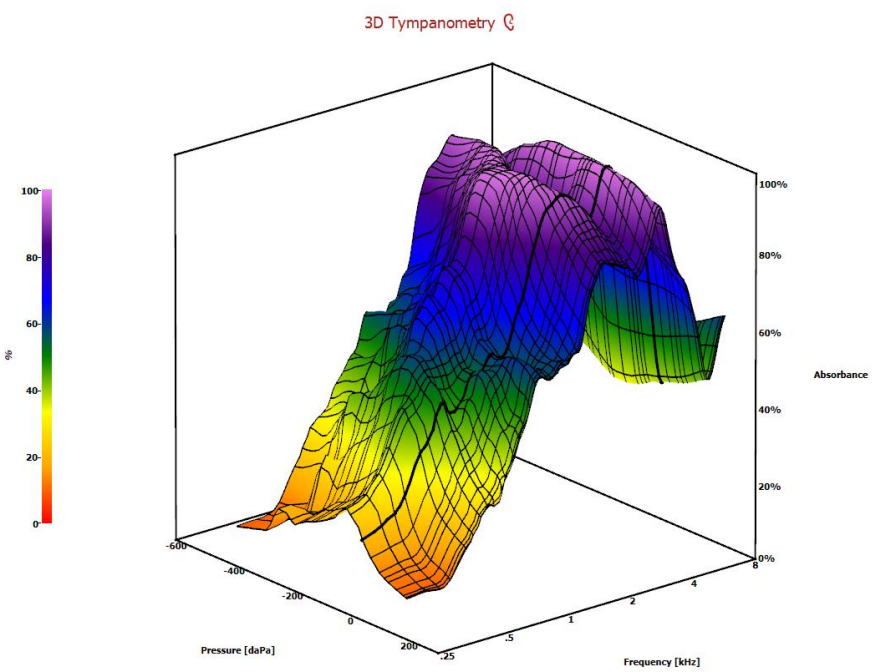
- 3-months-old at time of study visit
  - 3rd ABR evaluation at CCHMC
- Failed NBHS in both ears
- Full-term birth via emergency c-section due to failure of labor progression
- No known risk factors for hearing loss
- At 3 weeks: Mild SNHL, normal tymps, absent DPs, ? Air-bone gap?
- At 7 weeks: Mild Conductive Loss, ? Bone, Neg Pressure tymps

Broad Band Tympanometry



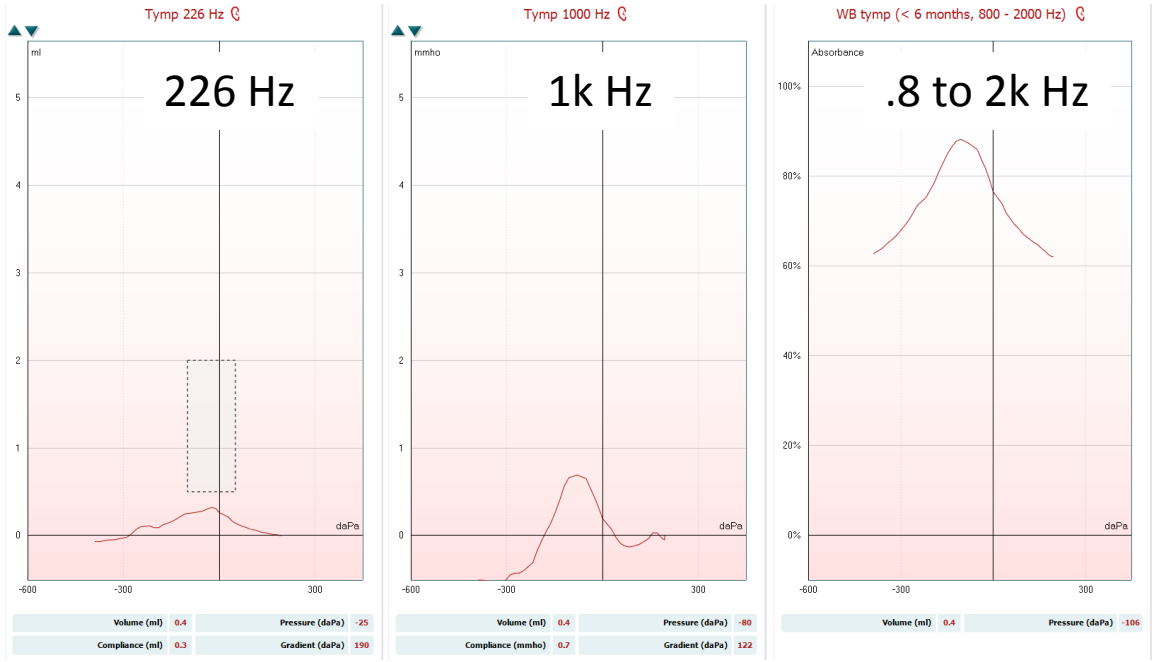
Left Ear



Right Ear

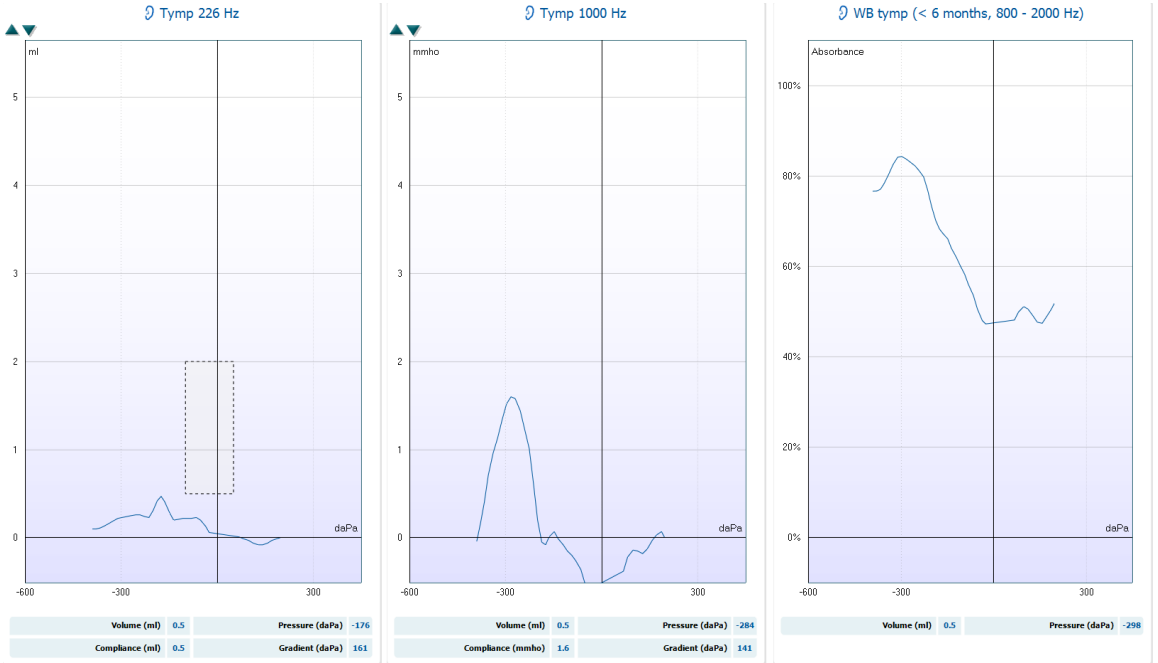
Subject 2672 3 Months

Right Ear



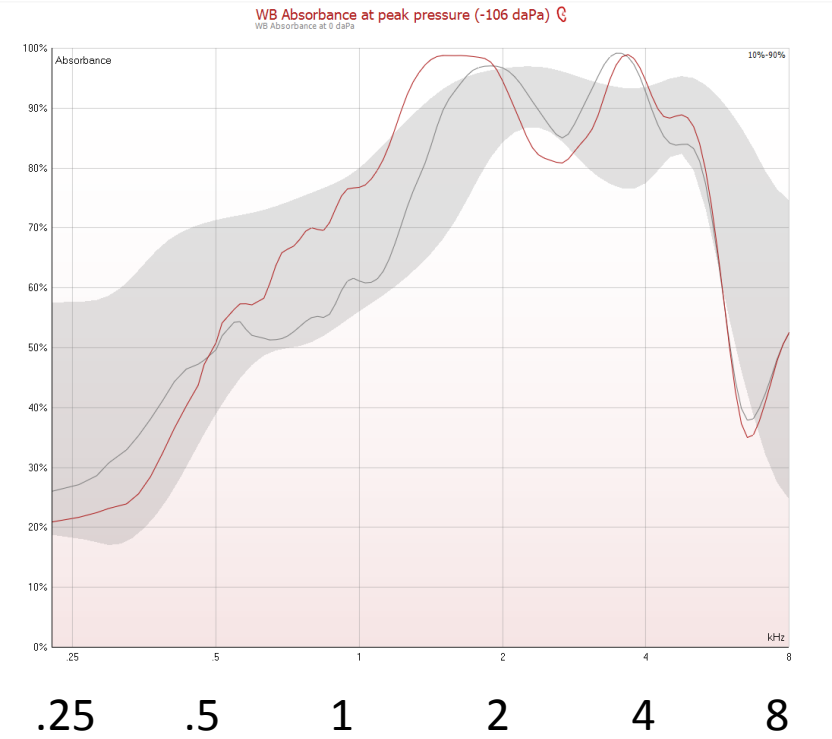
Subject 2672
3 Months

Left Ear



Wide Band Absorbance

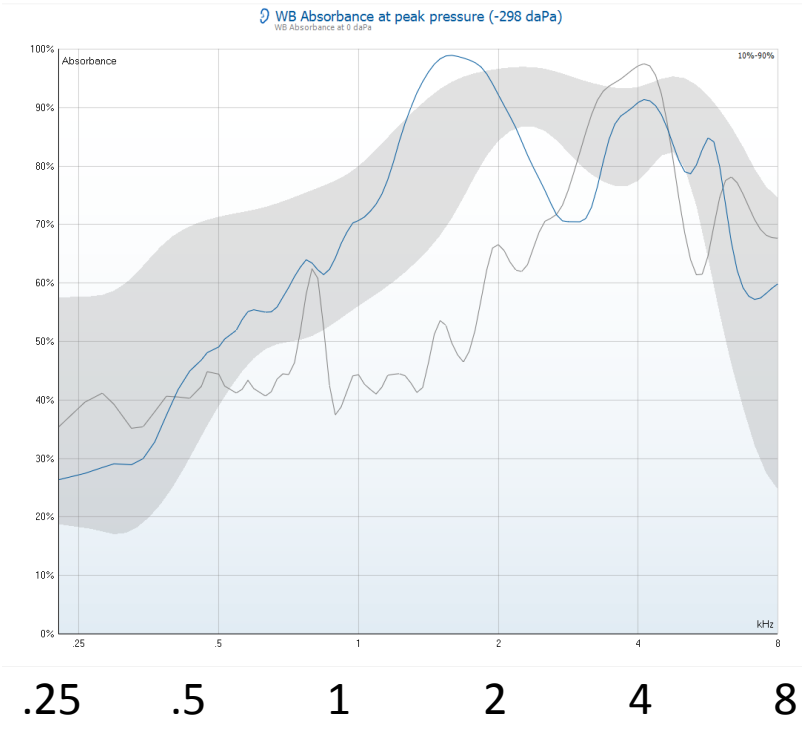
Right Ear



.25 .5 1 2 4 8

Frequency in kHz

Left Ear

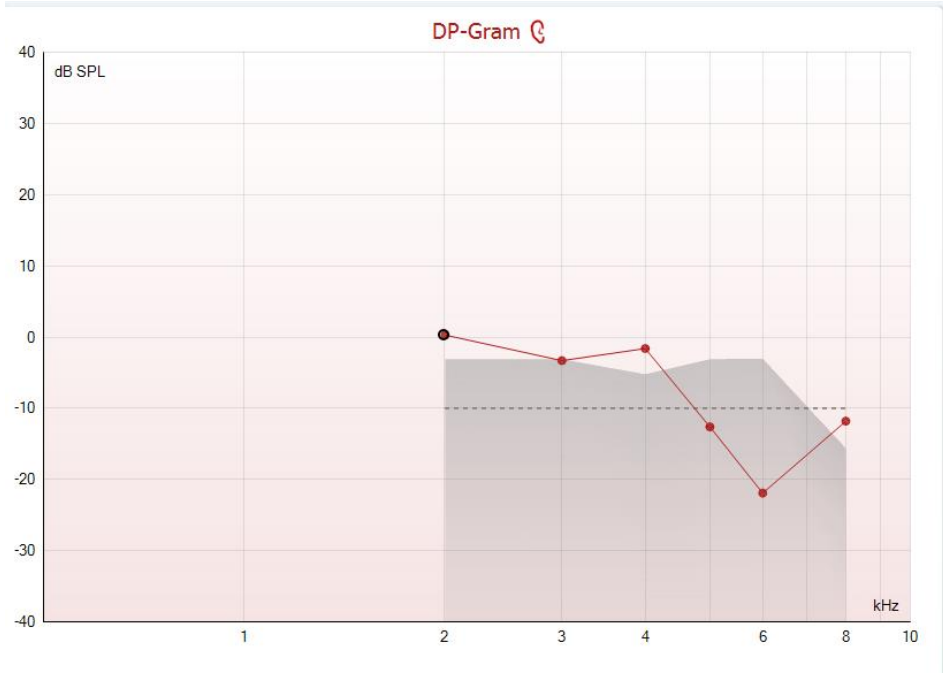


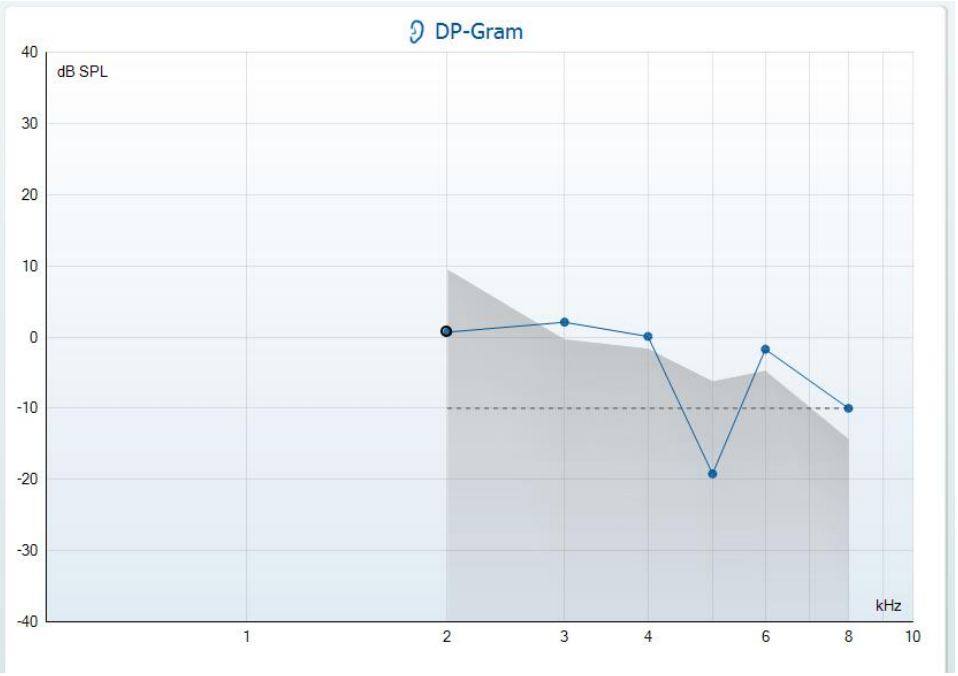
.25 .5 1 2 4 8

Frequency in kHz

Subject 2672 3 Months

DPOAEs

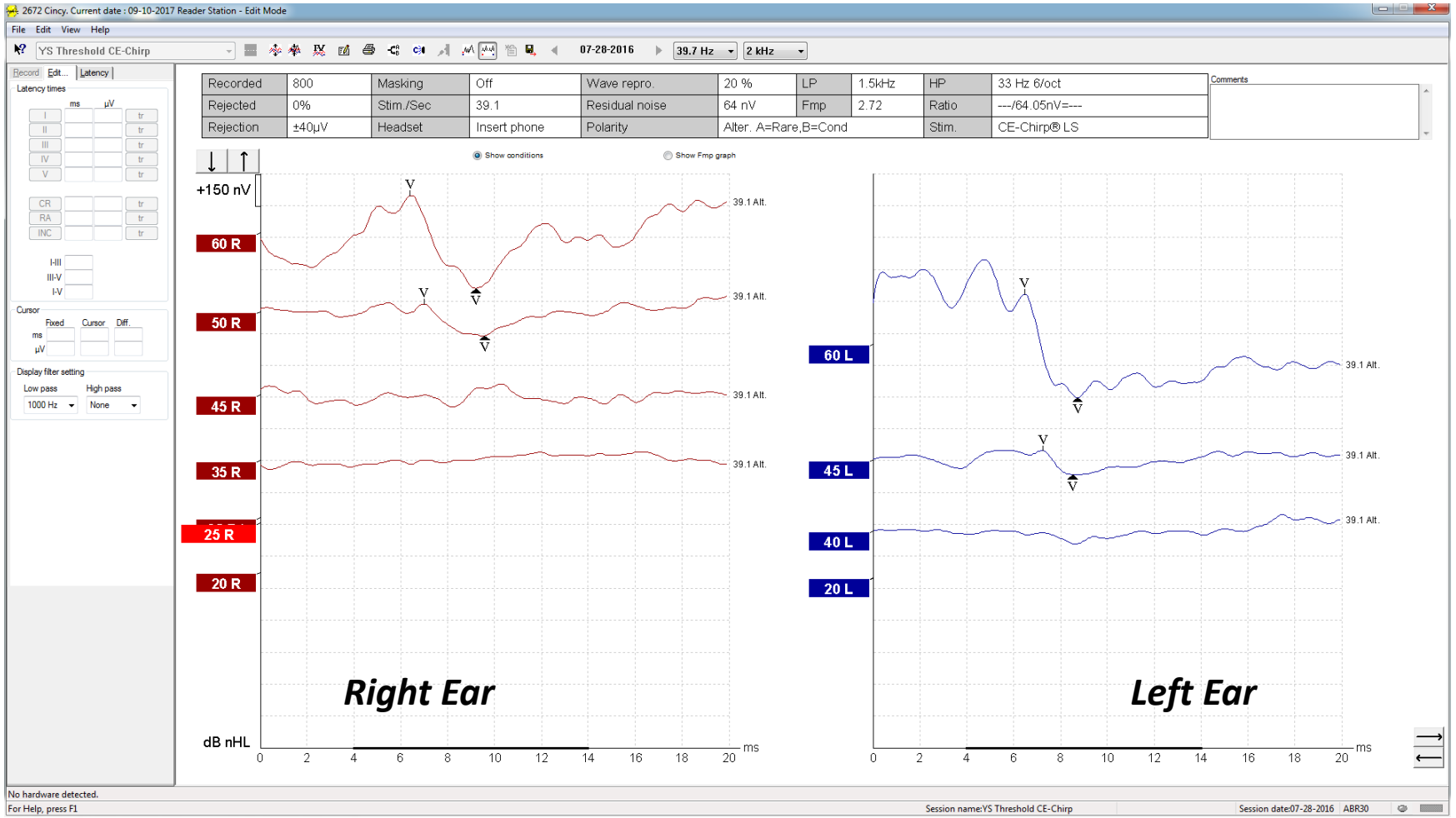




Right Ear ***Left Ear***

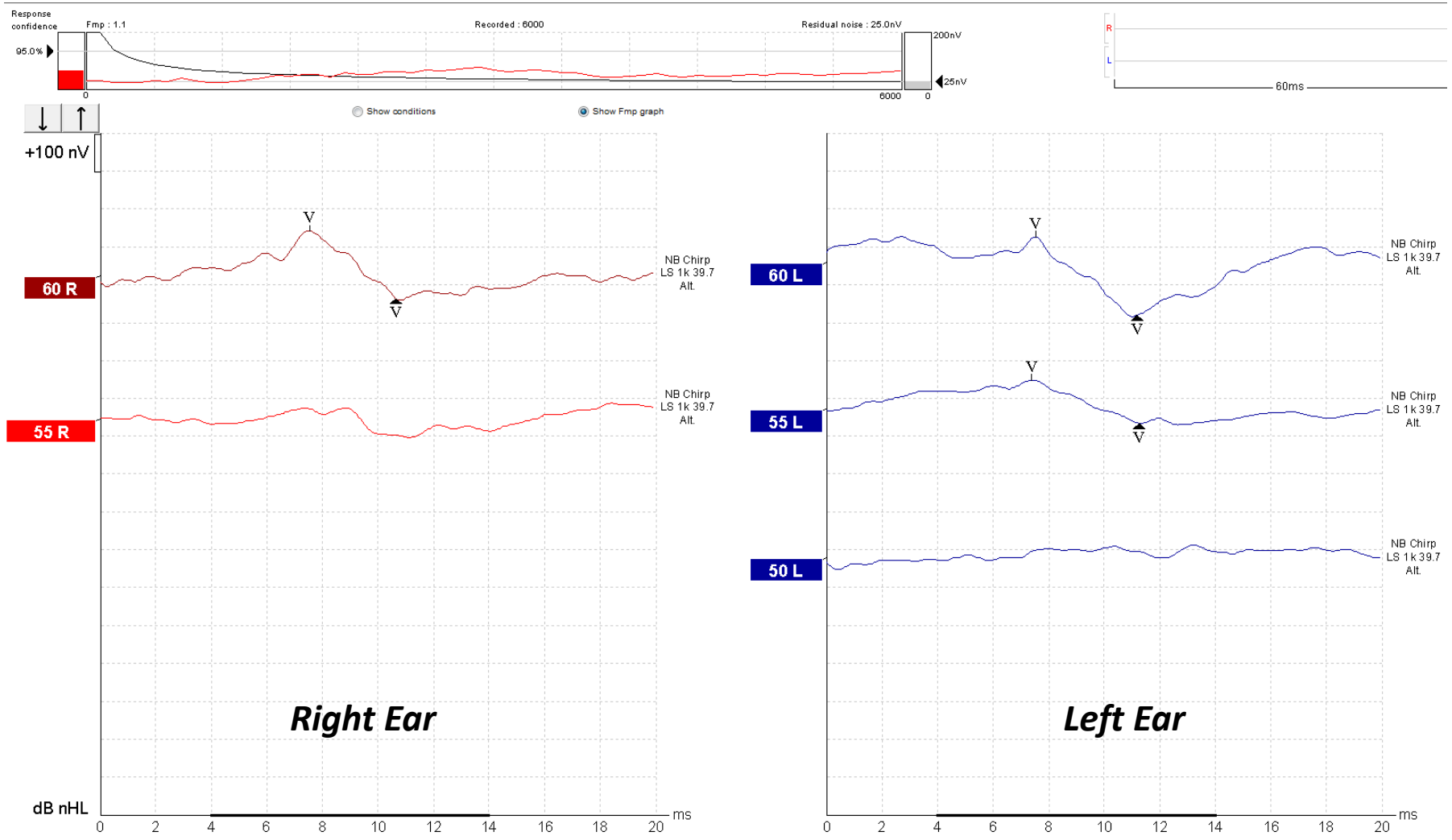
Subject 2672 3 Months

Broad Band CE-Chirp ABR Threshold
50 dB Right Ear and 45 dB Left Ear



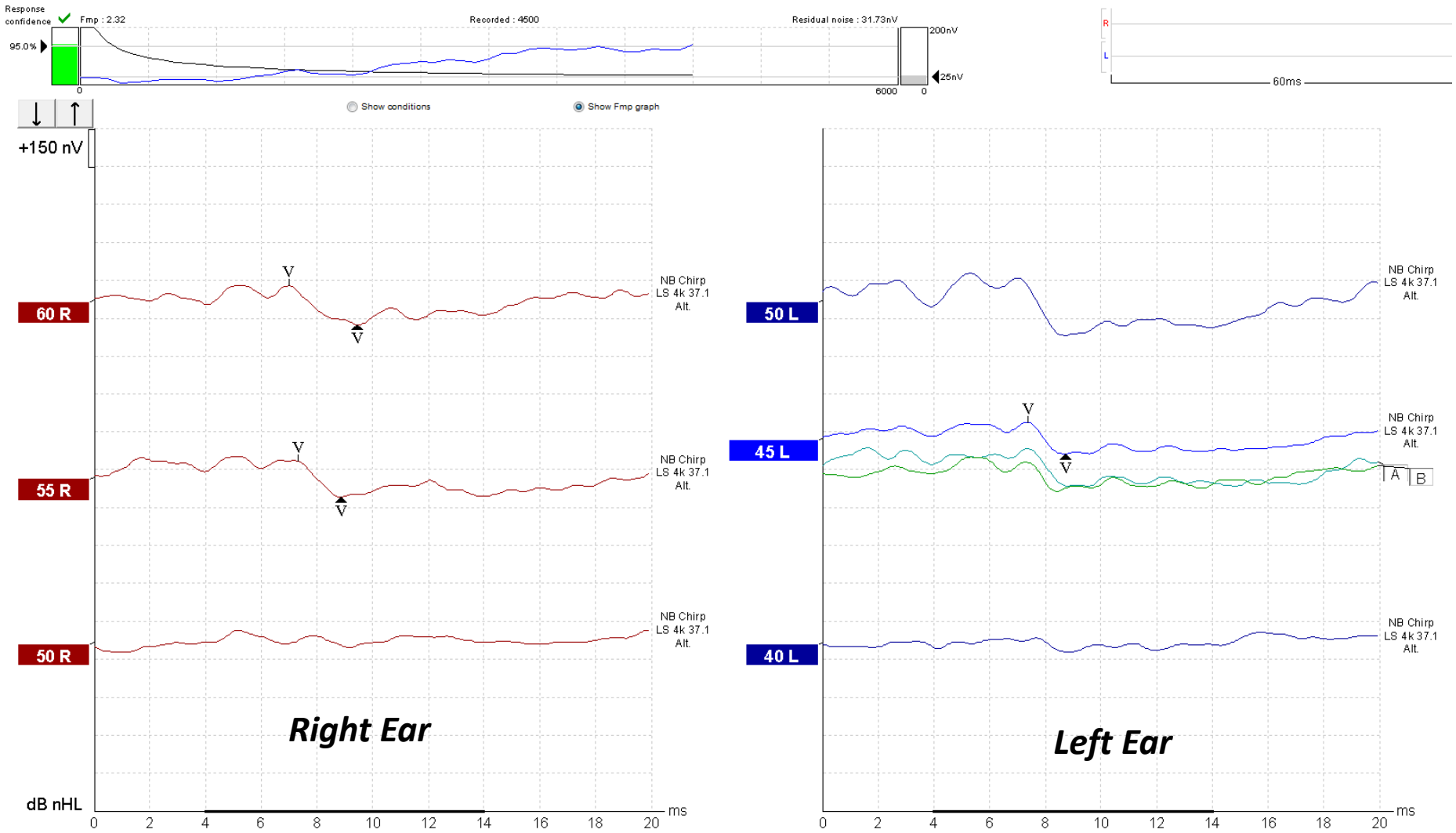
Subject 2672 3 Months

1k Hz 60 dB Right Ear and 55 dB Left Ear



Subject 2672 3 Months

4k Hz 55 dB Right and 45 dB Left



Reproducibility

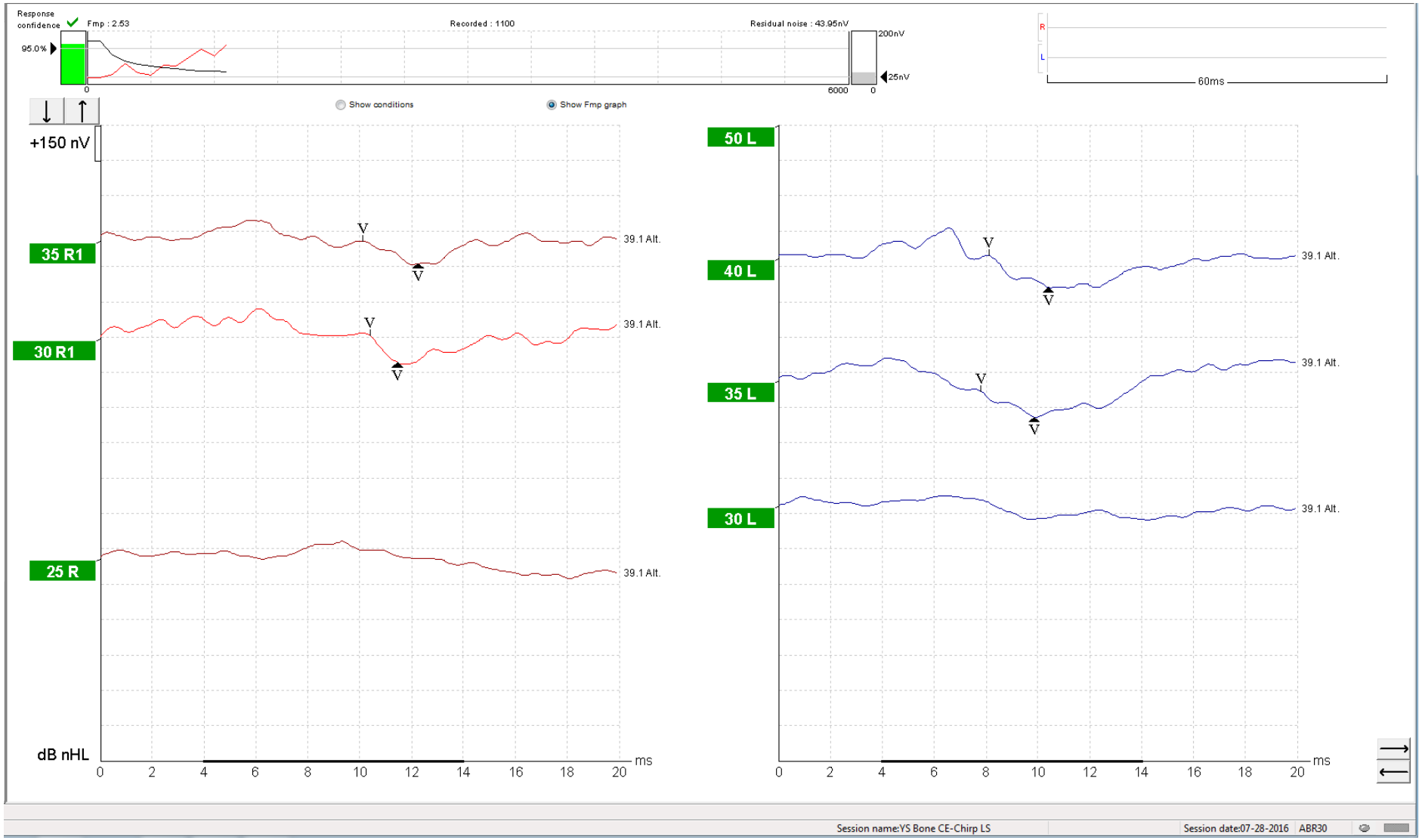
80 %

92%

0%

Subject 2672 3 Months

BB Chirp Bone Threshold = 30 & 35 dB



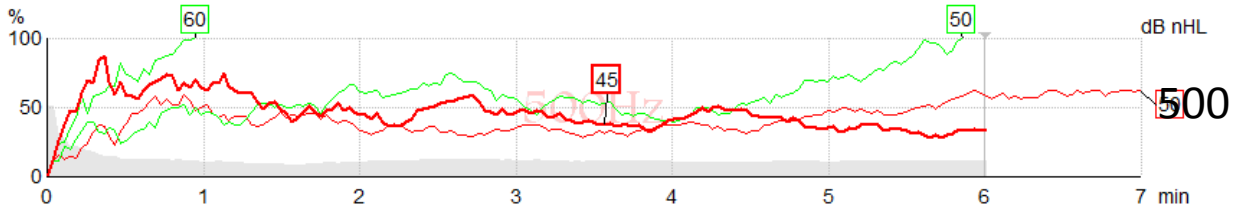
Subject 2672 3 Months

ASSR

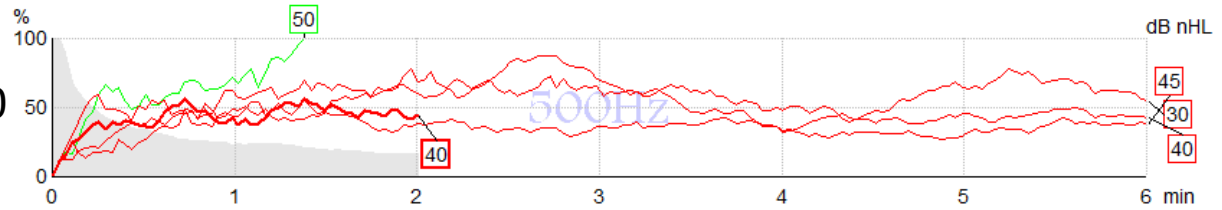
Subject 2672 3 Months

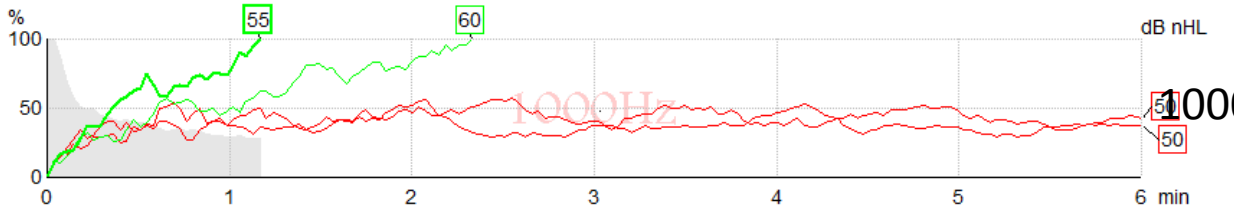
Right Ear

Left Ear

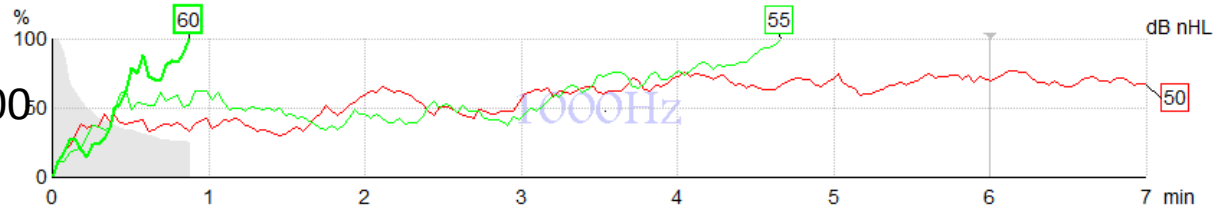


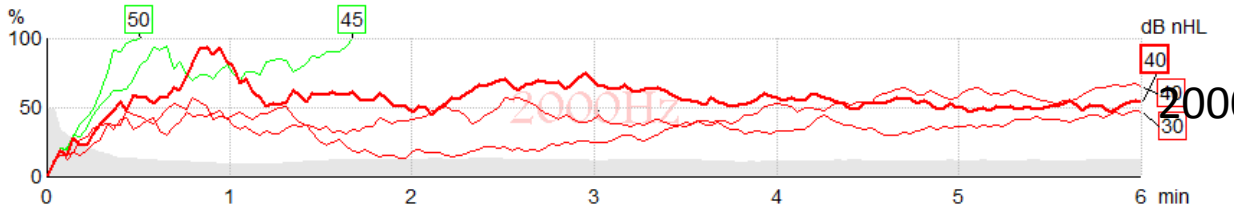
500



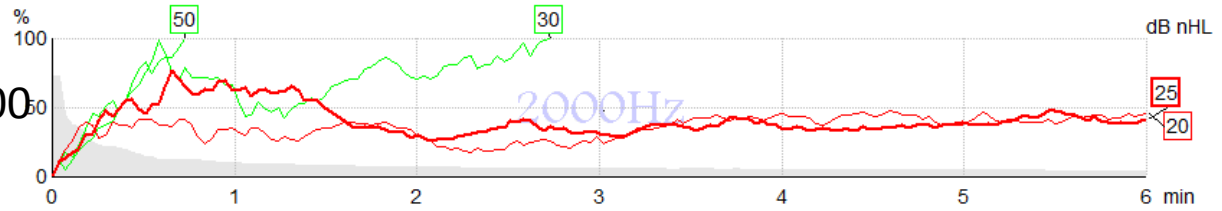


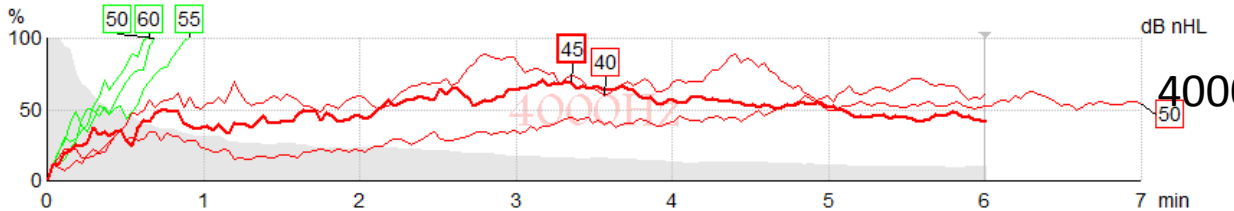
1000



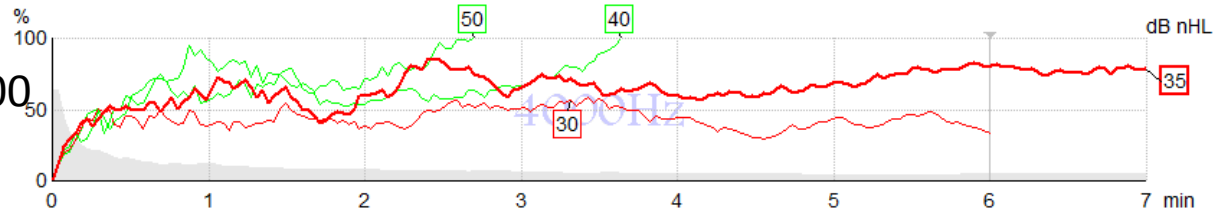


2000





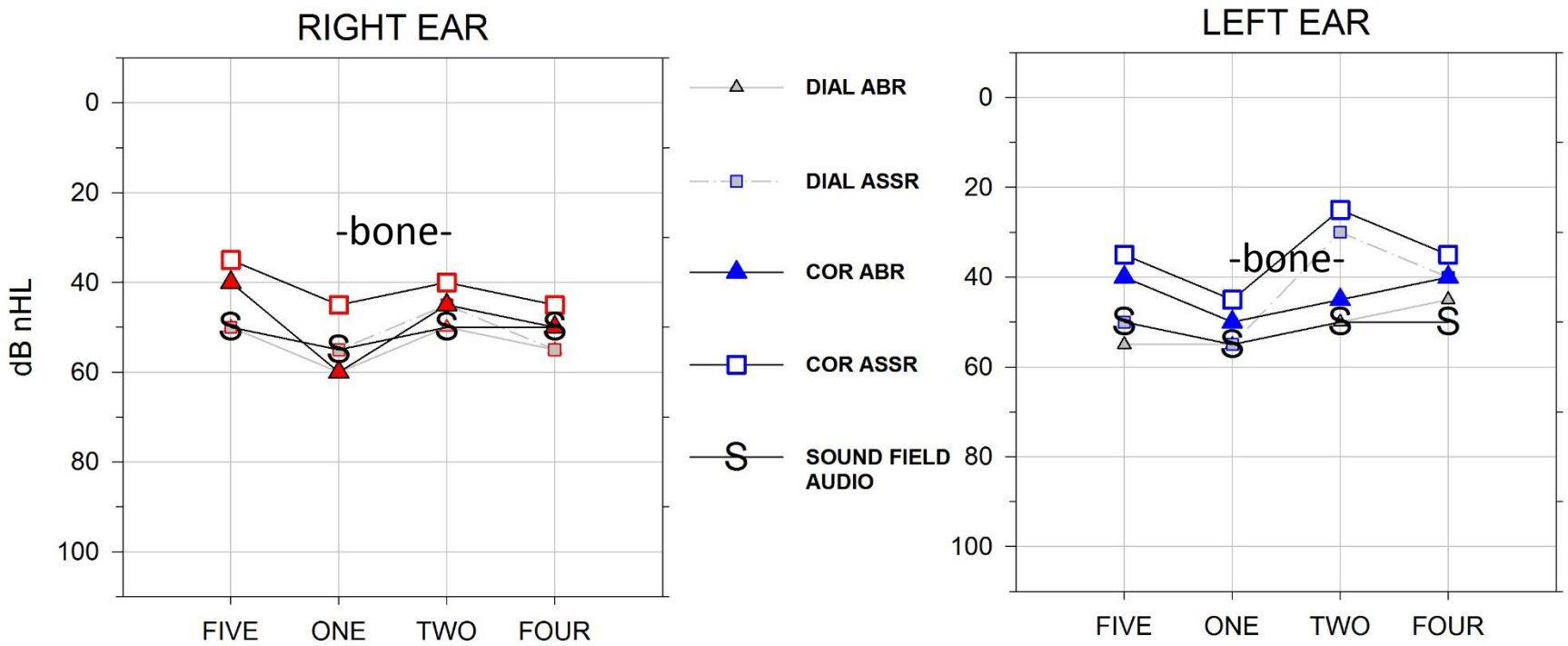
4000

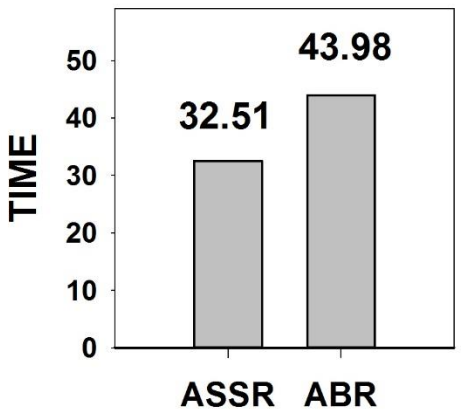


dB nHL	500Hz	1kHz	2kHz	4kHz
20				
25				
30			47% 31nV	
35				
40			54% 29nV	62% 18nV
45	33% 27nV		100% 17nV	41% 25nV
50	100% 11nV	43% 10nV	100% 157nV	100% 29nV
55		100% 68nV		100% 32nV

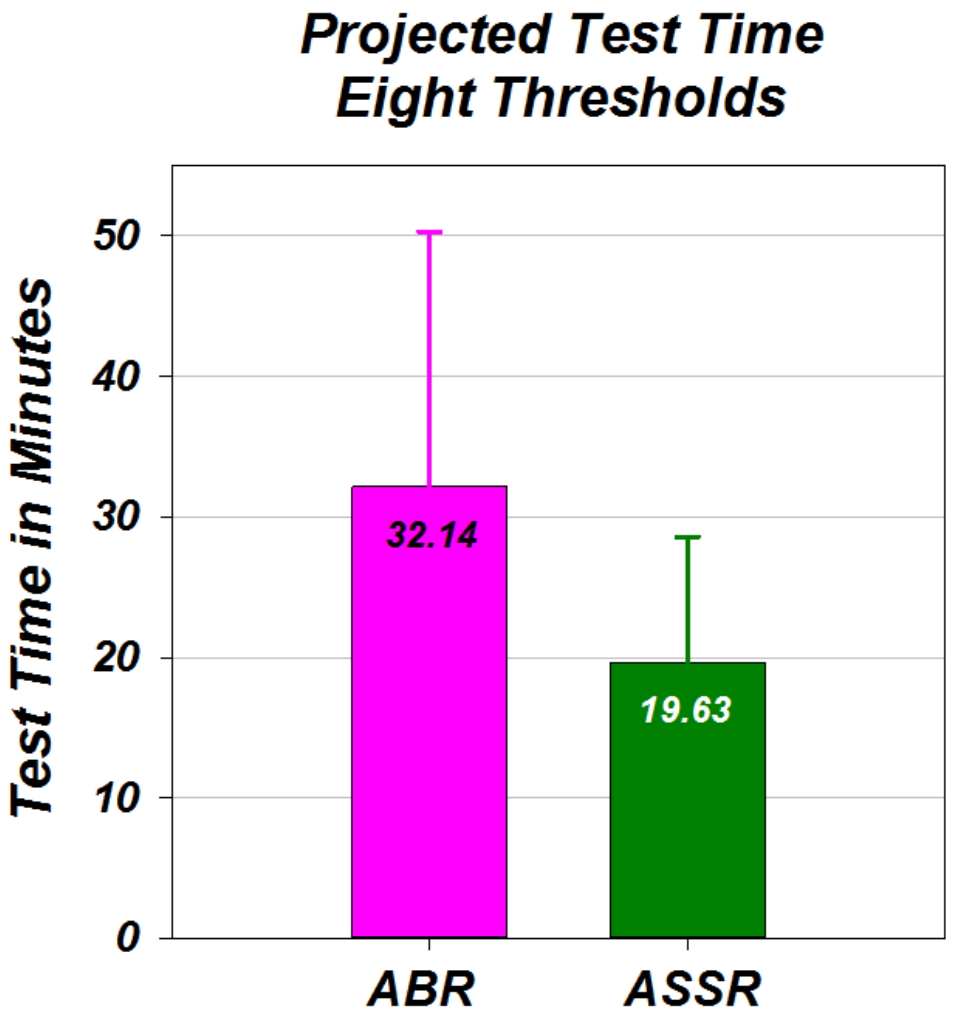
dB nHL	500Hz	1kHz	2kHz	4kHz
20			47% 14nV	
25			42% 11nV	
30	55% 35nV		100% 87nV	33% 20nV
35				84% 13nV
40	45% 41nV			100% 14nV
45	38% 17nV			
50	100% 102nV	65% 38nV	100% 137nV	100% 84nV
55		100% 20nV		

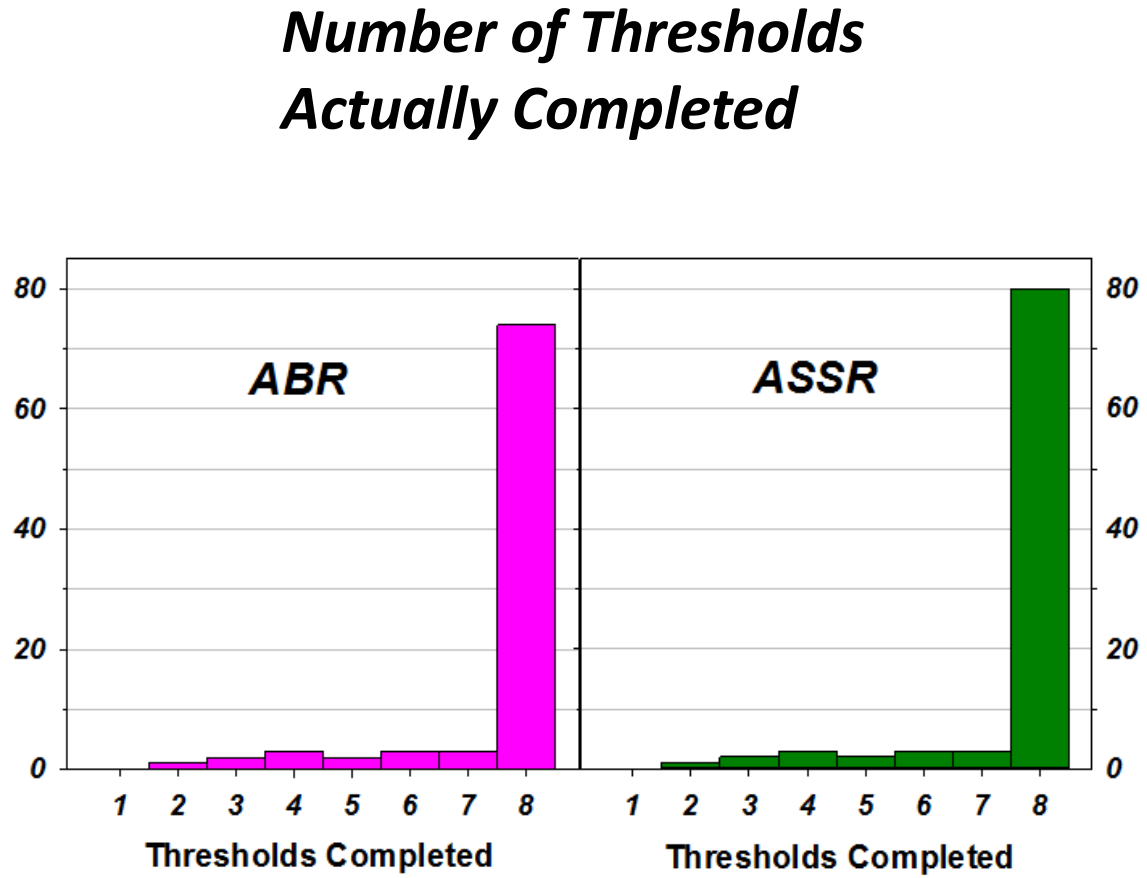
2672 3 Months - Natural Sleep - Failed Screening





TEST TIME


Projected Test Time
Eight Thresholds
Test Time in Minutes
50
40
30
20
10
0
32.14
19.63
ABR
ASSR


Number of Thresholds
Actually Completed
80
60
40
20
0
ABR
ASSR
1 2 3 4 5 6 7 8
Thresholds Completed
Thresholds Completed

QUESTIONS??