Innovations in Verification of Hearing Aid Fitting in Children

ANSI-standard for RECD, use of MAOF and SII normative range compared in common measurement systems

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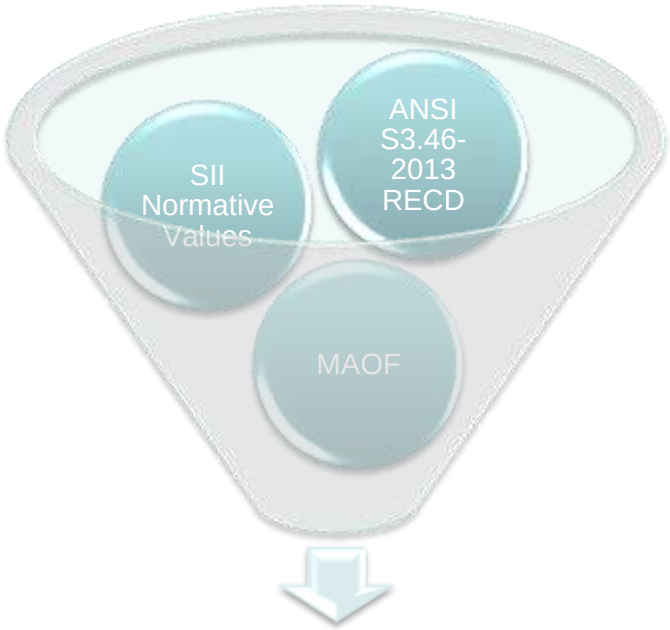
Hörakustik-Meisterin, Pädakustikerin

Requirements in Verification

- Standardization of the RECD measurement
  - ANSI S3.46-2013 / RECD
- SII Normative Values for children
  - PaedAmp, University of Western Ontario
- MAOF-range as target for frequency lowering
  - Maximum Audible Output Frequency Range
  - PaedAmp, University of Western Ontario



Implication on / Application in common Verification Equipment

www.dslio.com

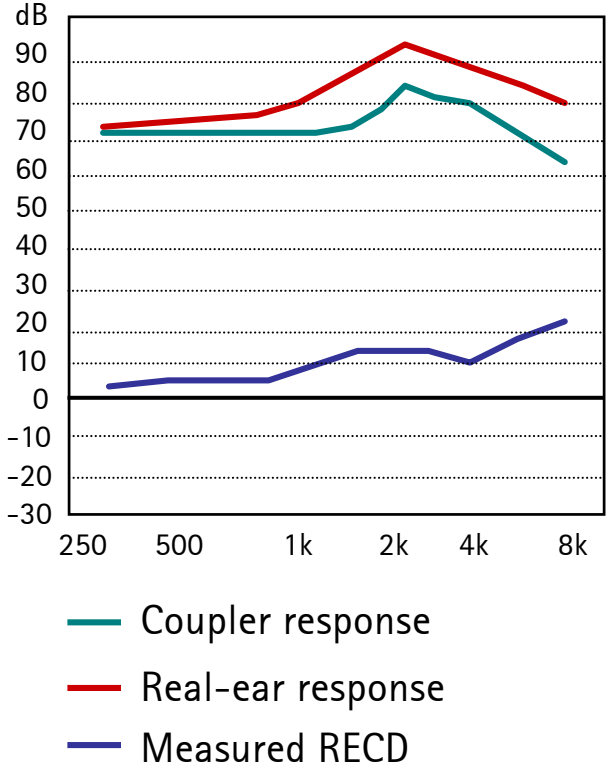
Innovation, accuracy, application and implementation

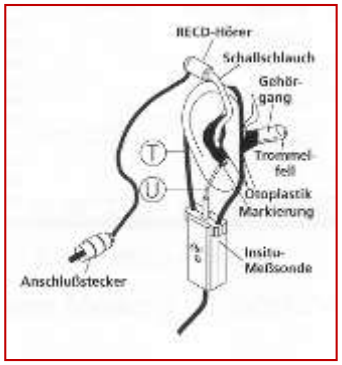
RECD

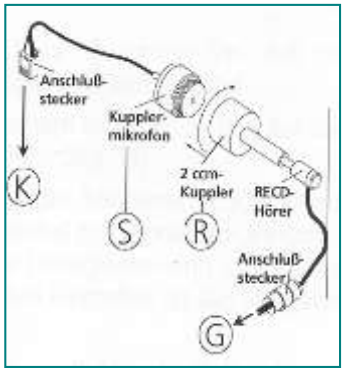
RECD “classic”

Basic measurement principle since 1995 by use of the HA2 coupler:

dB SPL(real ear) – dB SPL(HA2 coupler) = RECD







ANSI Standard S3.46-2013 / RECD

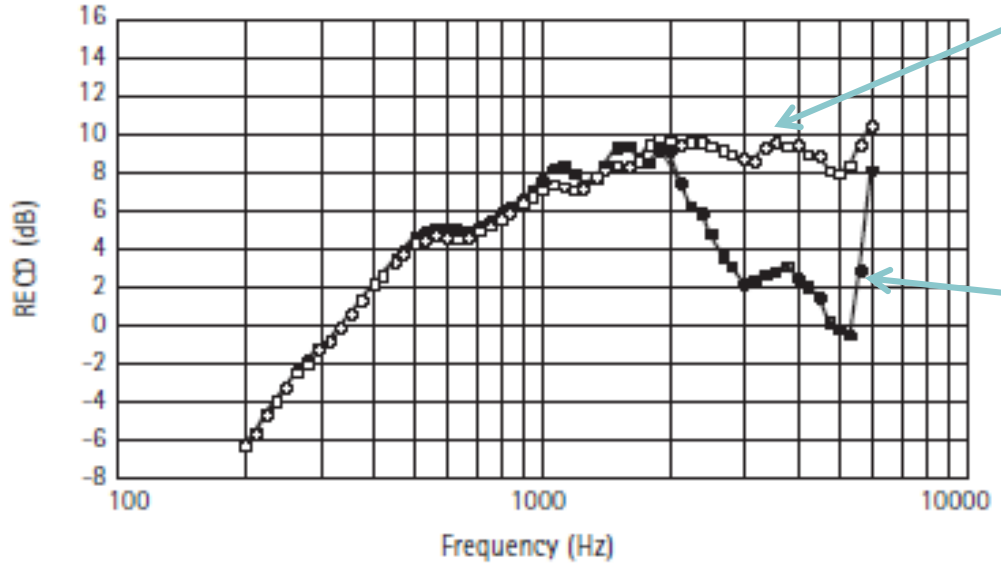
- ANSI S3.46: North American Standard for REM
  - 2013: RECD included in S3.46 recommends to
    - use of HA1 coupler
    - use of a high-impedance transducer for signal application
    - use of ear mold / foam tip for both – coupler and on ear measurement
  - Why?
  - Consequences?
  - Changes in Application?

RECD – Accuracy of method

Type of coupler

Figure 2

The RECDs obtained from the data in Figure 1. These were obtained by subtracting the SPL generated in the occluded ear canal from the SPL generated in the HA1 (open circles) and the HA2 (black circles) 2-cc coupler.



HA1-RECD
with ITE-coupler

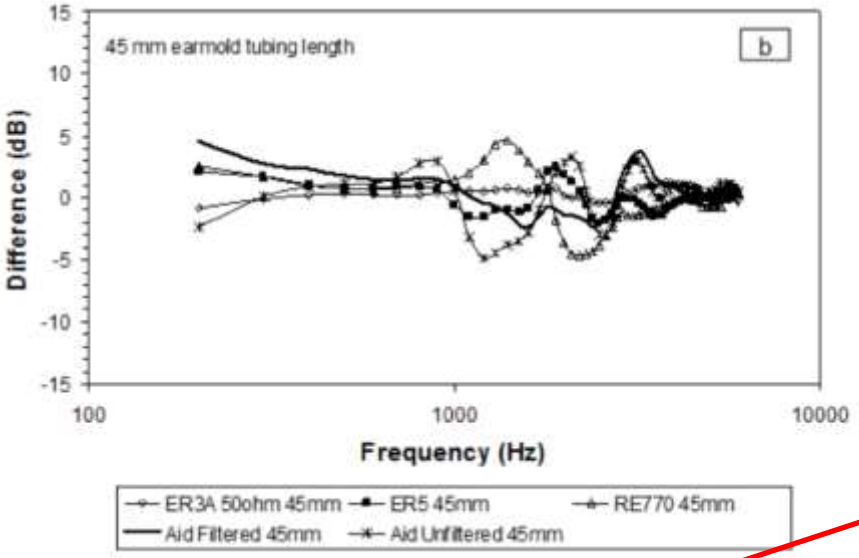
HA2-RECD
with BTE-coupler

Bagatto et al. 2005: Clinical Protocols for Hearing Instrument Fitting

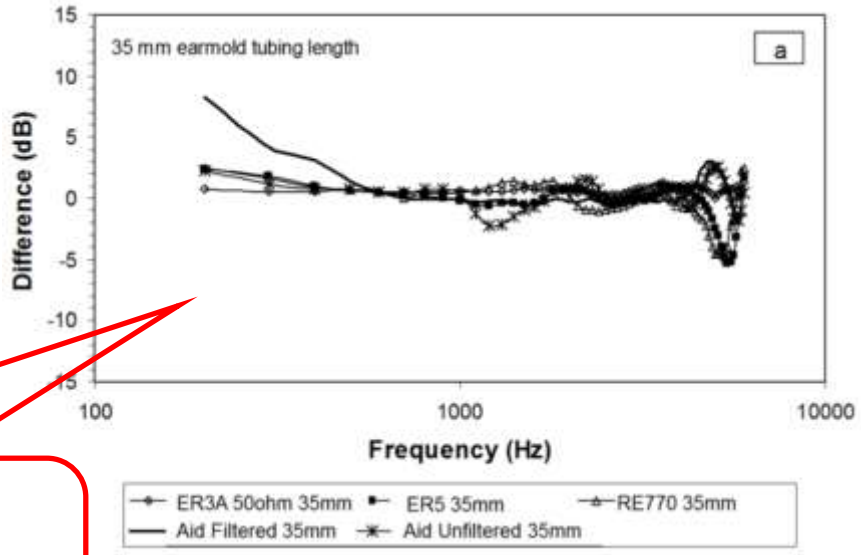
RECD – Accuracy of method

Transducer and earmold tubing length

Earmold tubing length: 45 mm



Earmold tubing length: 35 mm



The shorter the earmold tubing length:

- The fewer resonances
- the lower the impact of different RECD transducers

Bagatto et al. 2005: Clinical Protocols for Hearing Instrument Fitting

RECD – Accuracy of method

RECD with foam tip vs. individual earmold

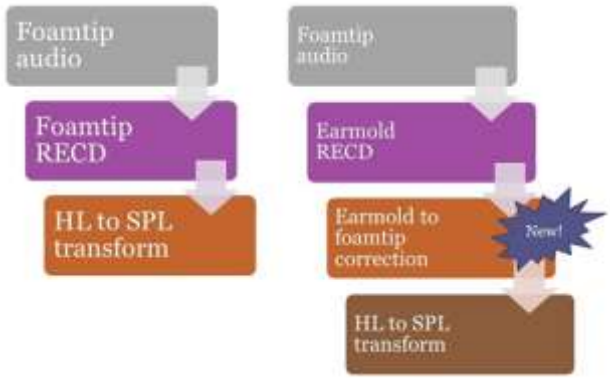
- Earmold tubing length
  - Short and standard for ear tips
  - Longer and individual in earmolds
- Used for
  - Audiometry with inserts: ear tips
  - HA fitting: earmold
- Consequence for RECD:
  - High precision requires two RECDs!

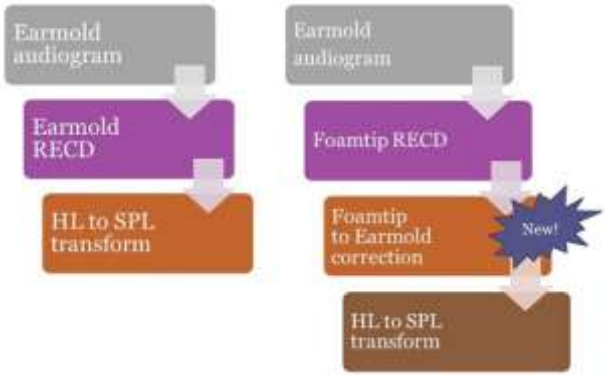
RECD – Accuracy of method

Foam tip to earmold difference

- Age-related RECD averages exist for foam tip and for earmold
- the hearing loss may have been measured with foam tip, while the HA is couple with earmold
  - Measure RECD twice?
  - Develop correction values!

- Corrective Values developed and implemented in Verifit VF2





Western

New RECDs and New ANSI Standards: Revisiting RECD Basics and Applications, Susan Scollie, 2015 (www.audiology-online.com)

Variances of couplers – used for RECD

HA1(2)-RECD ✓
recalculated

Verifit1, RM500SL, Axiom

HA1-RECD ✓
coupler measured

Aurical, Verifit

HA1-RECD ✓
with RECD SPL-probe

Child 0-24 months

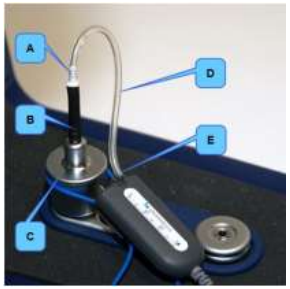
Affinity 2.0

WRECD ✓
recalculated to HA1-RECD

Verifit2 VF-2 with 0,4 cm^3-Kuppler

New software

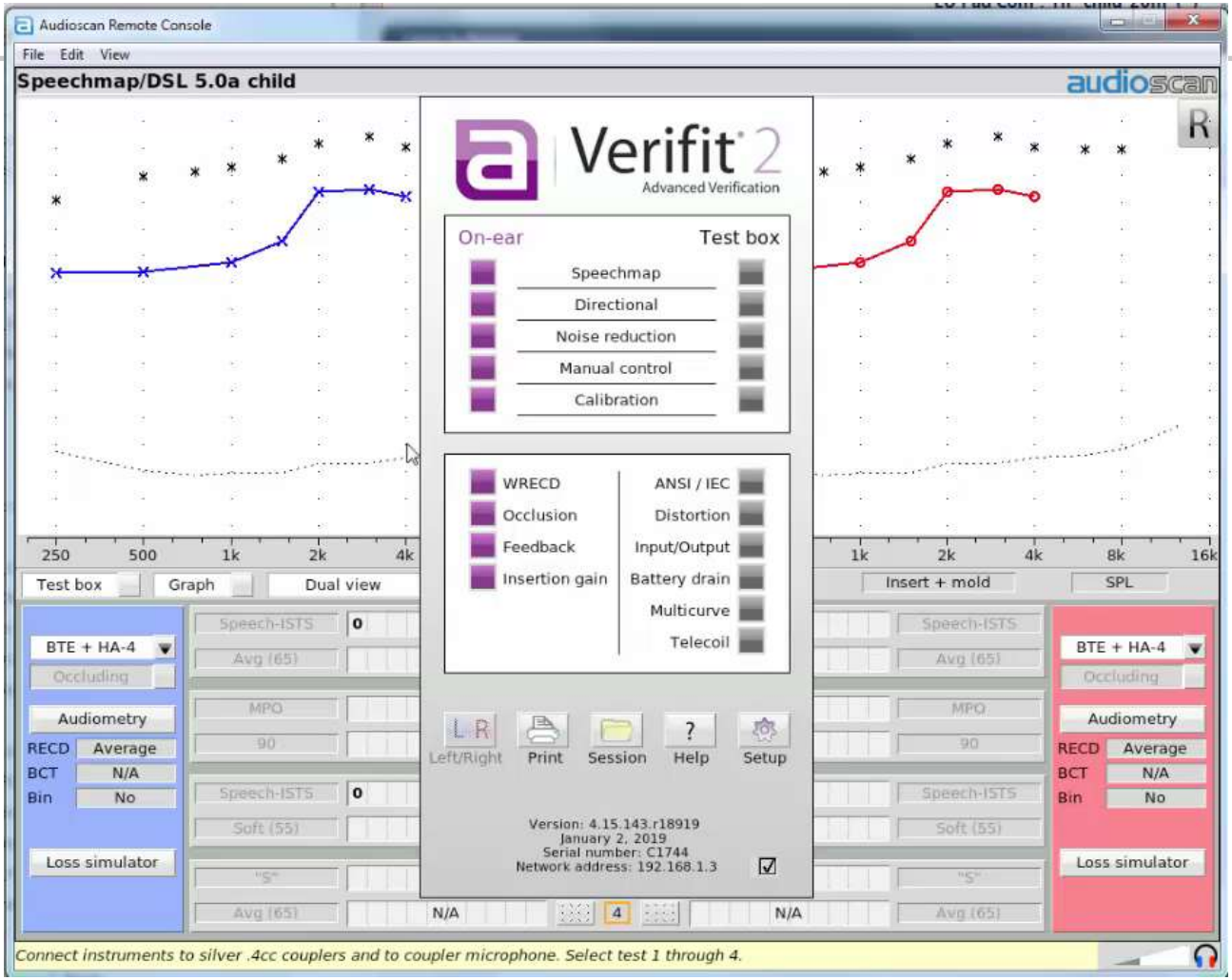
HA2-RECD



HA2-RECD

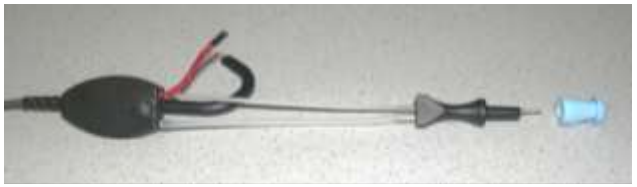
New software

WRECD with Verifit VF2 (Video)



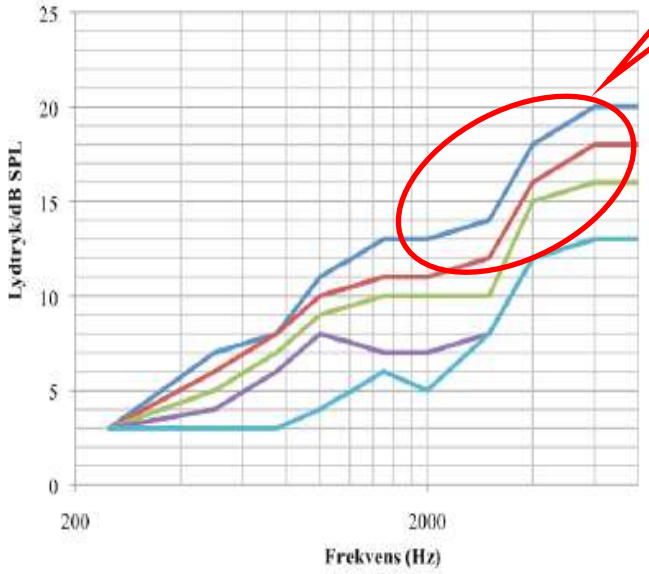
RECD SPL-Probe in Affinity

influence of insertion depth for RECD SPL probe vs. tube length in HA2-RECD

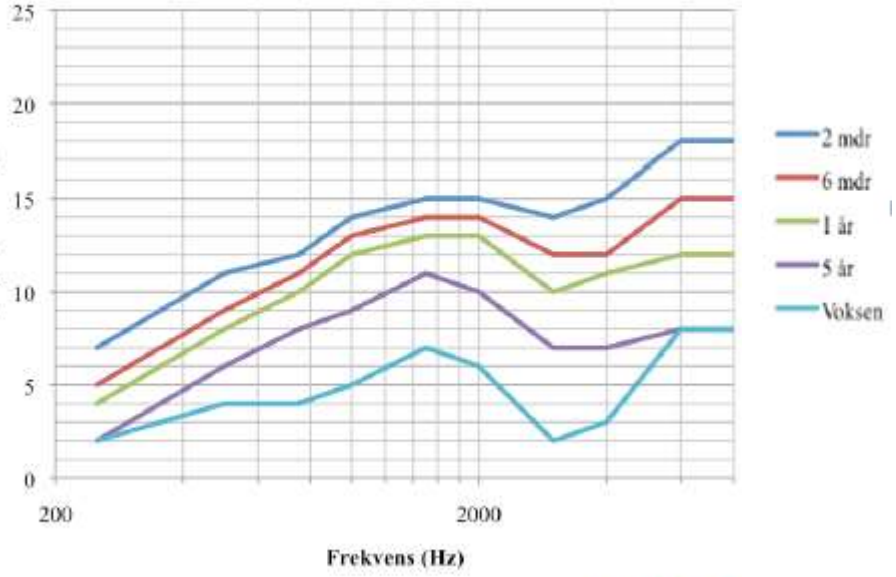


Comparable
with HA1-RECD

Age-related RECD measured with RECD-tip



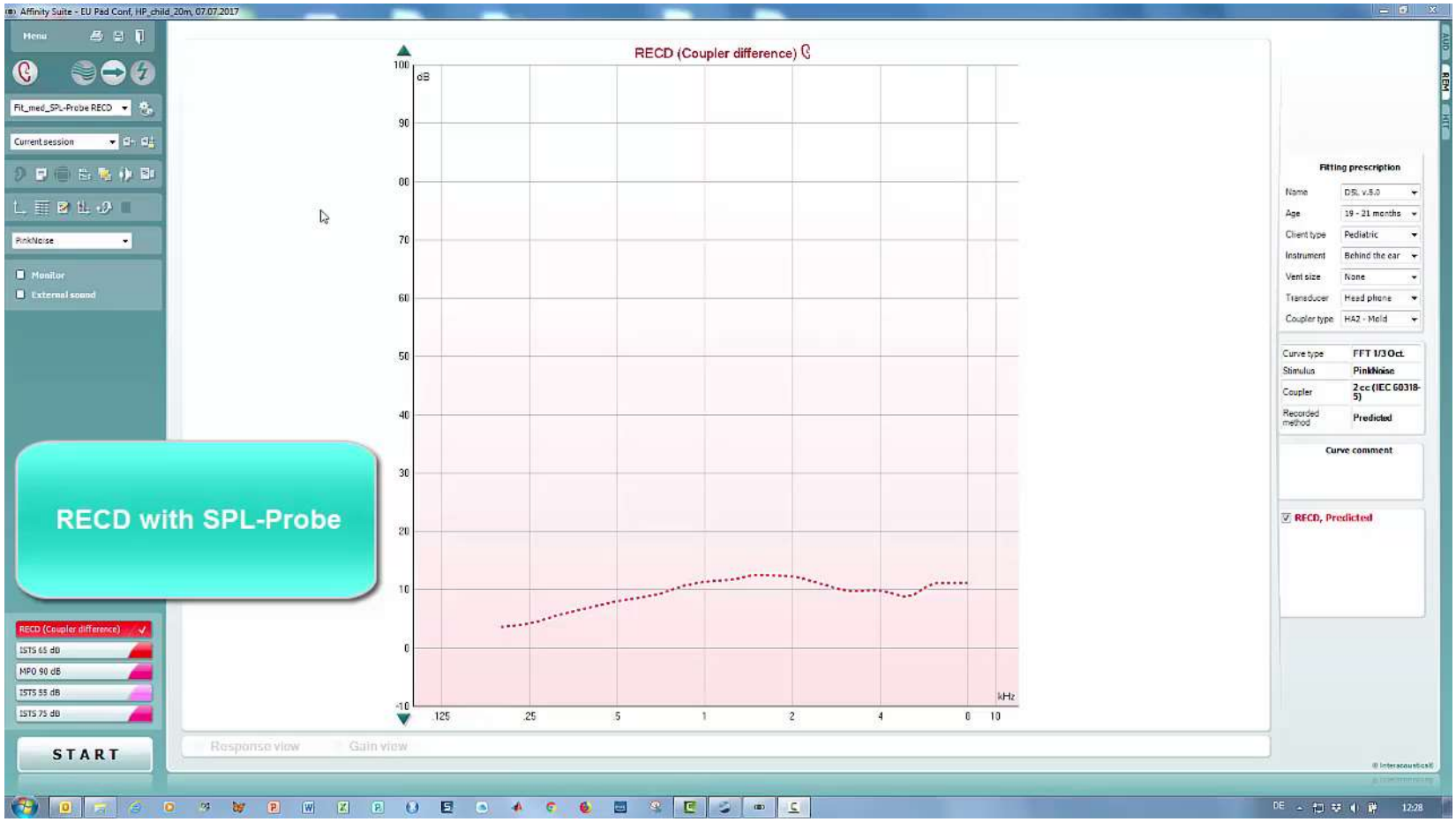
Age-related RECD with earmold measured with HA2-coupler



Source: Interacoustics

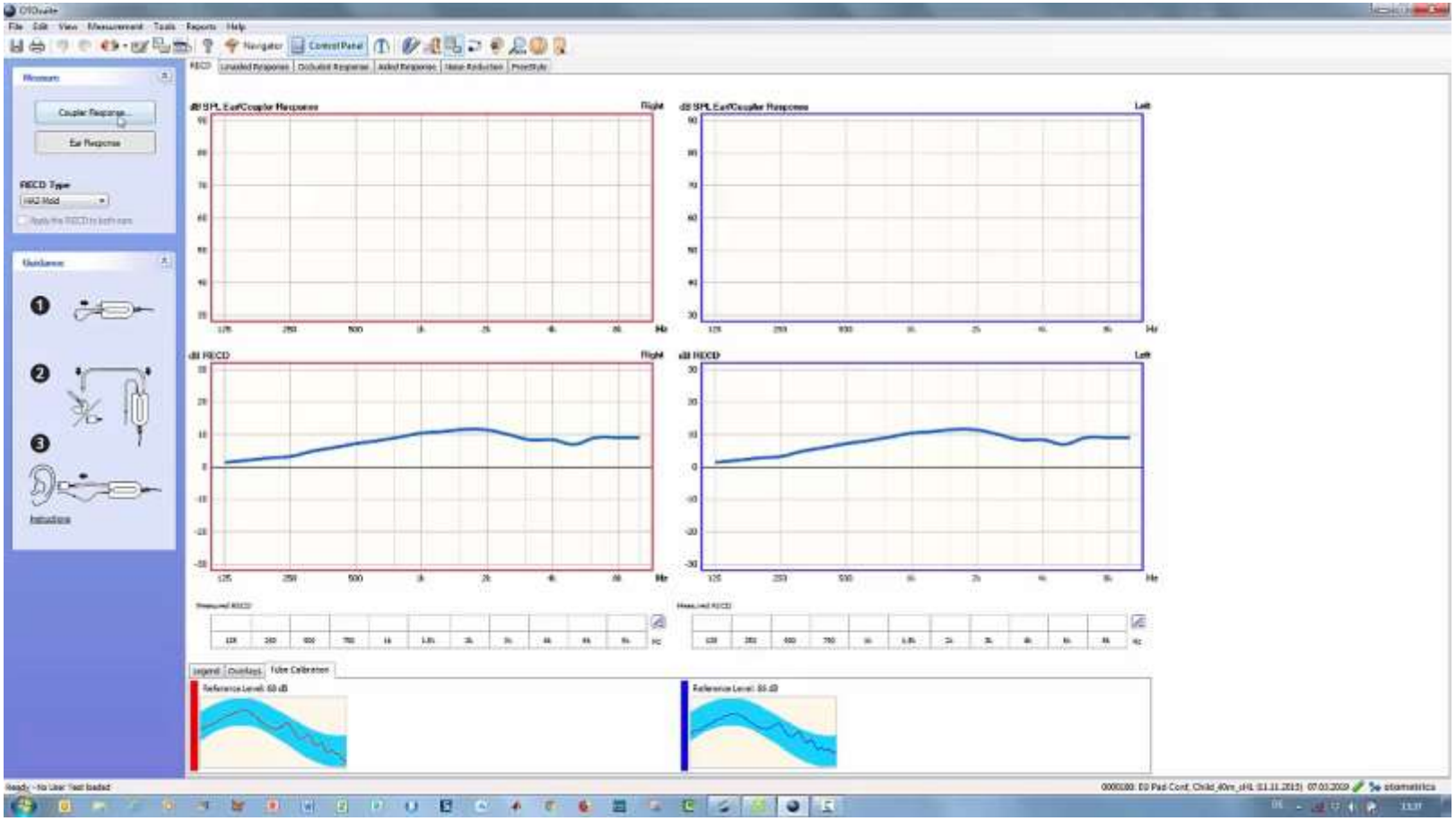
RECD with SPL probe (Video)

Example from Affinity 2.0



HA2-RECD with earmold (Video)

Example from Aurical

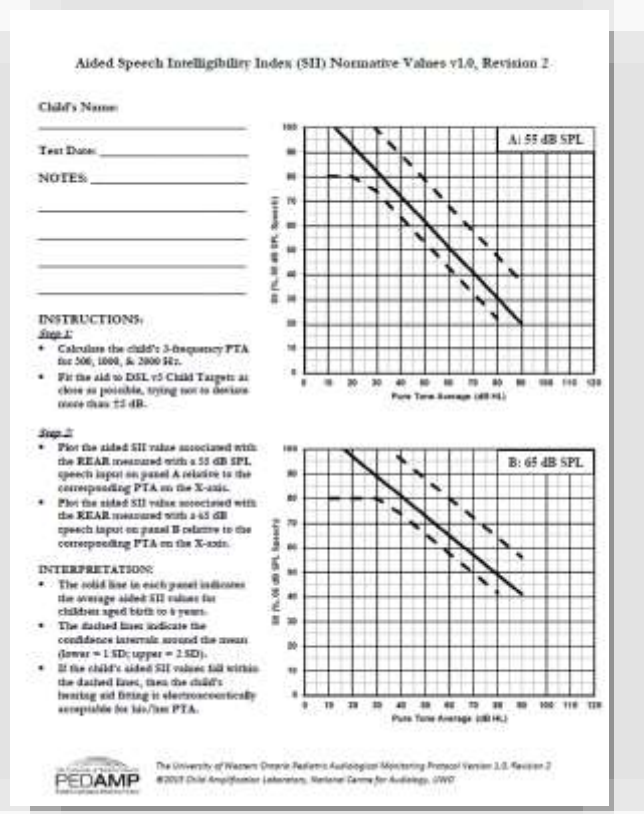


Normative Values for Paediatric Fitting Verification

SII

Fitting Evaluation: SII normative values

only for pediatric fitting! (DSL child)



Aided Speech Intelligibility Index (SII) Normative Values v1.0, Revision 2

Child's Name:

Test Date:

NOTES:

INSTRUCTIONS:

Step 1:

- Calculate the child's 3-frequency PTA for 500, 1000, & 2000 Hz.
- Fit the aid to DSL v5 Child Targets as close as possible, trying not to deviate more than ±5 dB.

Step 2:

- Plot the aided SII value associated with the REAR measured with a 55 dB SPL speech input on panel A relative to the corresponding PTA on the X-axis.
- Plot the aided SII value associated with the REAR measured with a 65 dB speech input on panel B relative to the corresponding PTA on the X-axis.

INTERPRETATION:

- The solid line in each panel indicates the average aided SII values for children aged birth to 6 years.
- The dashed lines indicate the confidence intervals around the mean (lower = 1 SD; upper = 2 SD).
- If the child's aided SII values fall within the dashed lines, then the child's hearing aid fitting is electroacoustically acceptable for his/her PTA.

A: 55 dB SPL

B: 65 dB SPL

Pure Tone Average (dB HL)

PEDAMP

The University of Western Ontario Pediatric Audiological Monitoring Protocol Version 1.0, Revision 2

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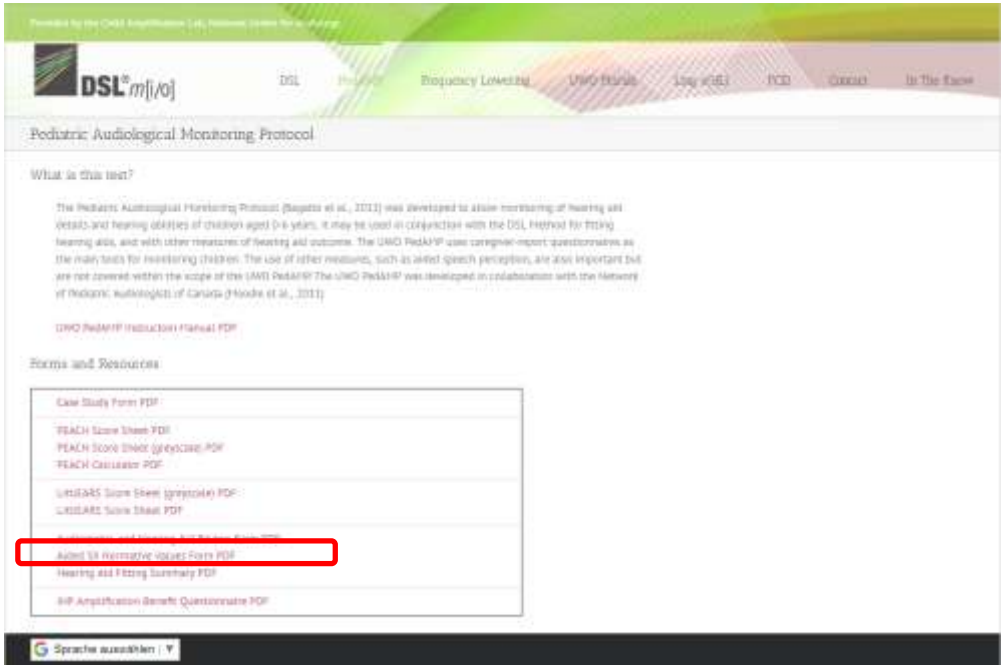
www.dslio.com

PedAMP → "Aided SII Normative Values Form PDF"



Source: Marlene P. Bagatto, 2012: "Development and Evaluation of an Audiological Outcome Measure Guideline for Use with Infants, Toddlers and Preschool Children"

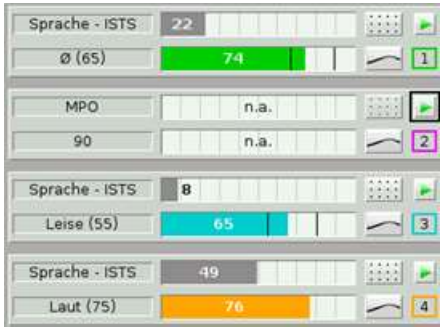
https://www.uwo.ca/nca/research/research_areas/cal/Publications.html

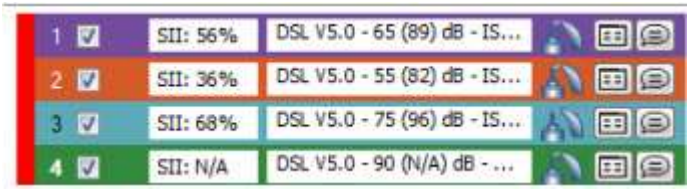
PTA & SII

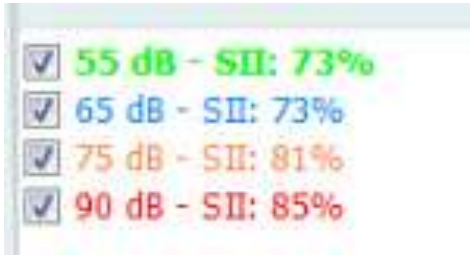
Calculation of PTA

$$PTA = \frac{HTL_{500\,Hz} + HTL_{1000\,Hz} + HTL_{2000\,Hz}}{3}$$

Calculation SII

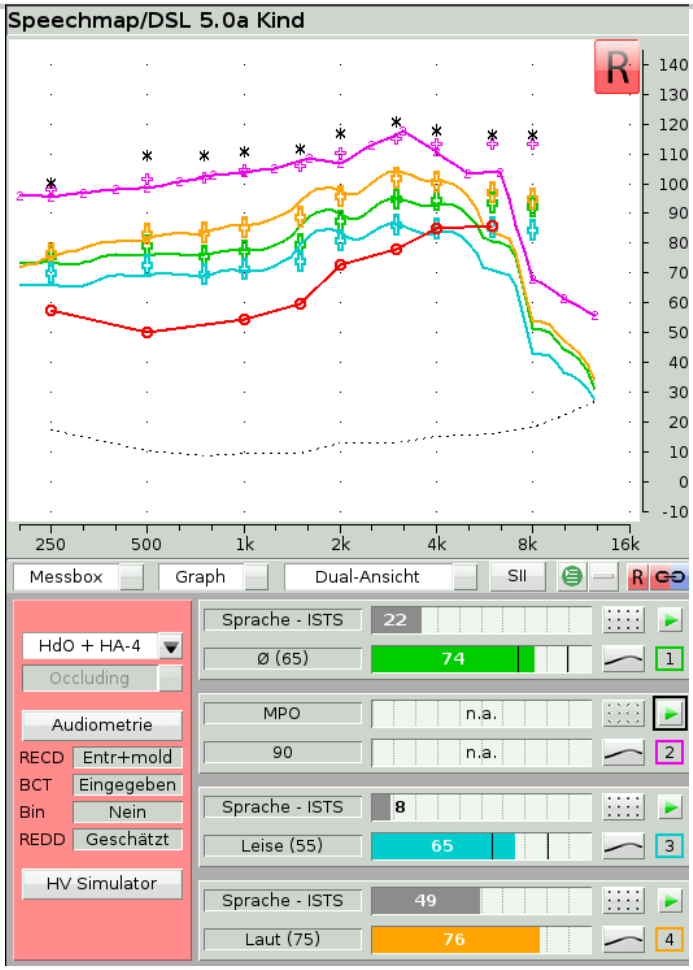






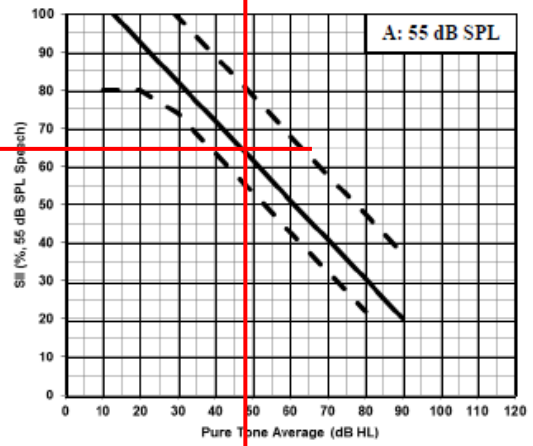
Normative Values for SII

Example from Audioscan Verifit VF2: calculation evaluated

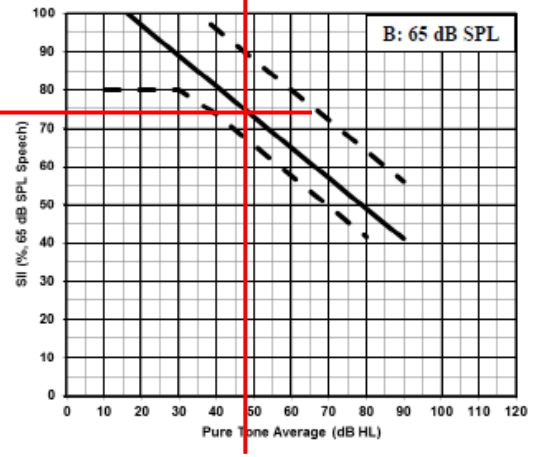


PTA: 48 dB HL

SII_{55dB} 65%



SII_{65dB} 74%



Comparison of Equipment used for Verification

VERIFICATION

Common REM Equipment in Pediatrics

- Software Versions of REM equipment used:
  - Affinity2.0 — *Affinity Suite Software Vers. 2.11.0*
  - Aurical HIT & FreeFit — *Otosuite Software Vers. 4.84.00*
  - Verifit & Verifit2 — *Verifit2 Software Vers.4.16.5*

- Essential:
  - **Simulated REM measurements** in test box with infants and young children
  - **RECD**: Real-Ear-to-Coupler measurement → Gold standard: measured
  - **ISTS** International Speech Test Signal
  - **Percentile analysis** used to display measurement results: LTASS, 99th percentile and 30th percentile used to display dynamics of speech

Aurical FreeFit und HIT

Affinity HIT und REM

Formally, all measure in the same way!

<u>Question</u>: Does that also mean that the display shows exactly the same measurement results?

Audioscan Verifit2

Audioscan Verifit

Introduction to the graphical display of REM simulated, coupler based Verification of Hearing Aids in:

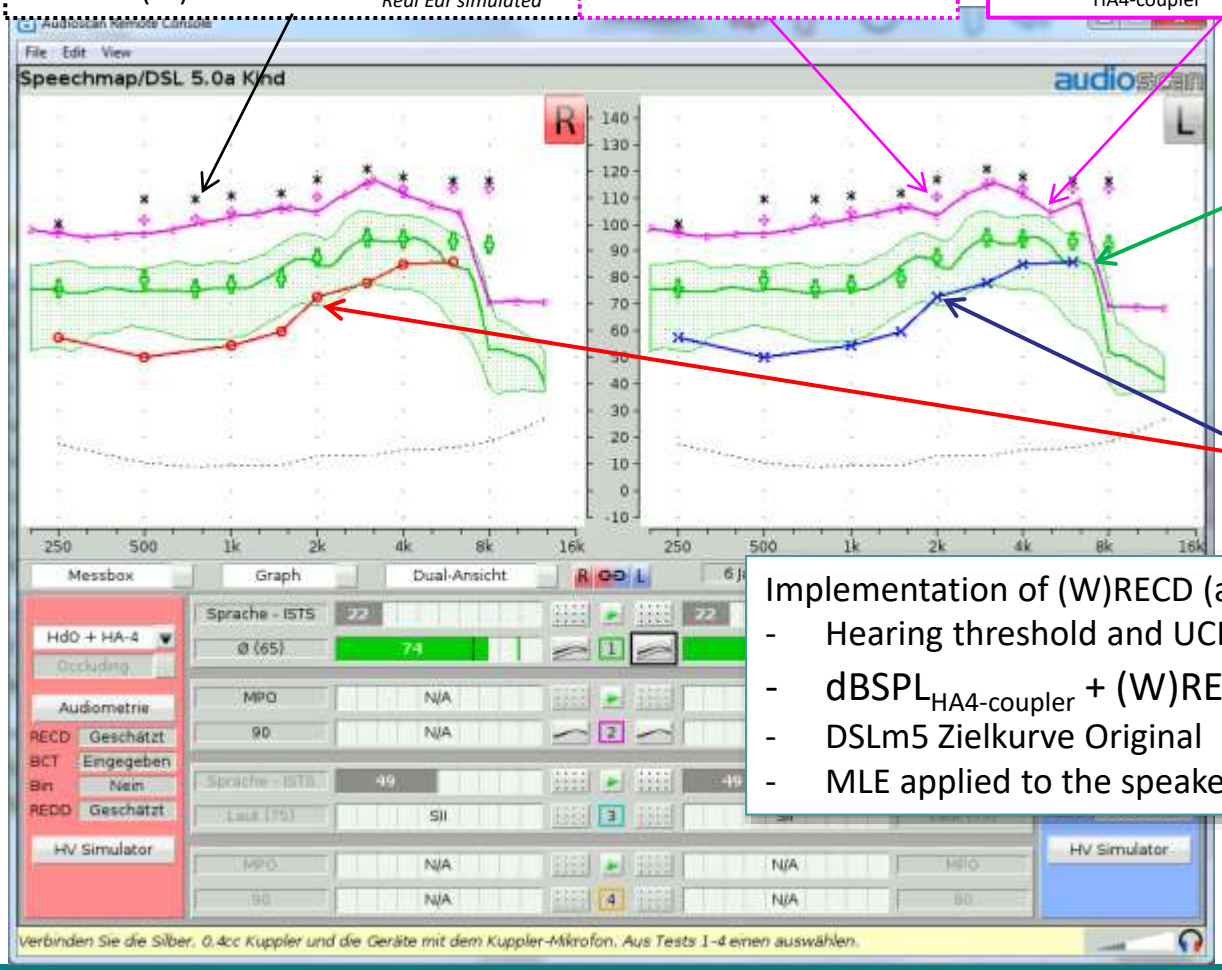
Verifit2, Aurical PMM, Affinity2.0,

Verifit2 / Verifit: Display coupler based REAR

*** UCL calculated (Pascoe) in dB SPL + (W)RECD = dB $SPL_{Real\ Ear\ simulated}$

+ + + BOLT target for MPO DSLv5

MPO measured in dB $SPL_{HA4\text{-}coupler}$ + (W)RECD



HA measured with ISTS 65 dB in dB $SPL_{HA4\text{-}coupler}$ + (W)RECD = dB $SPL_{Real\ Ear\ simulated}$

— LTASS

Dynamikbereich von ISTS

Hearing threshold right/left in dB HL + $RETSPL_{transducer}$ + (W)RECD = dB $SPL_{Real\ Ear\ simulated}$

Implementation of (W)RECD (average or measured):

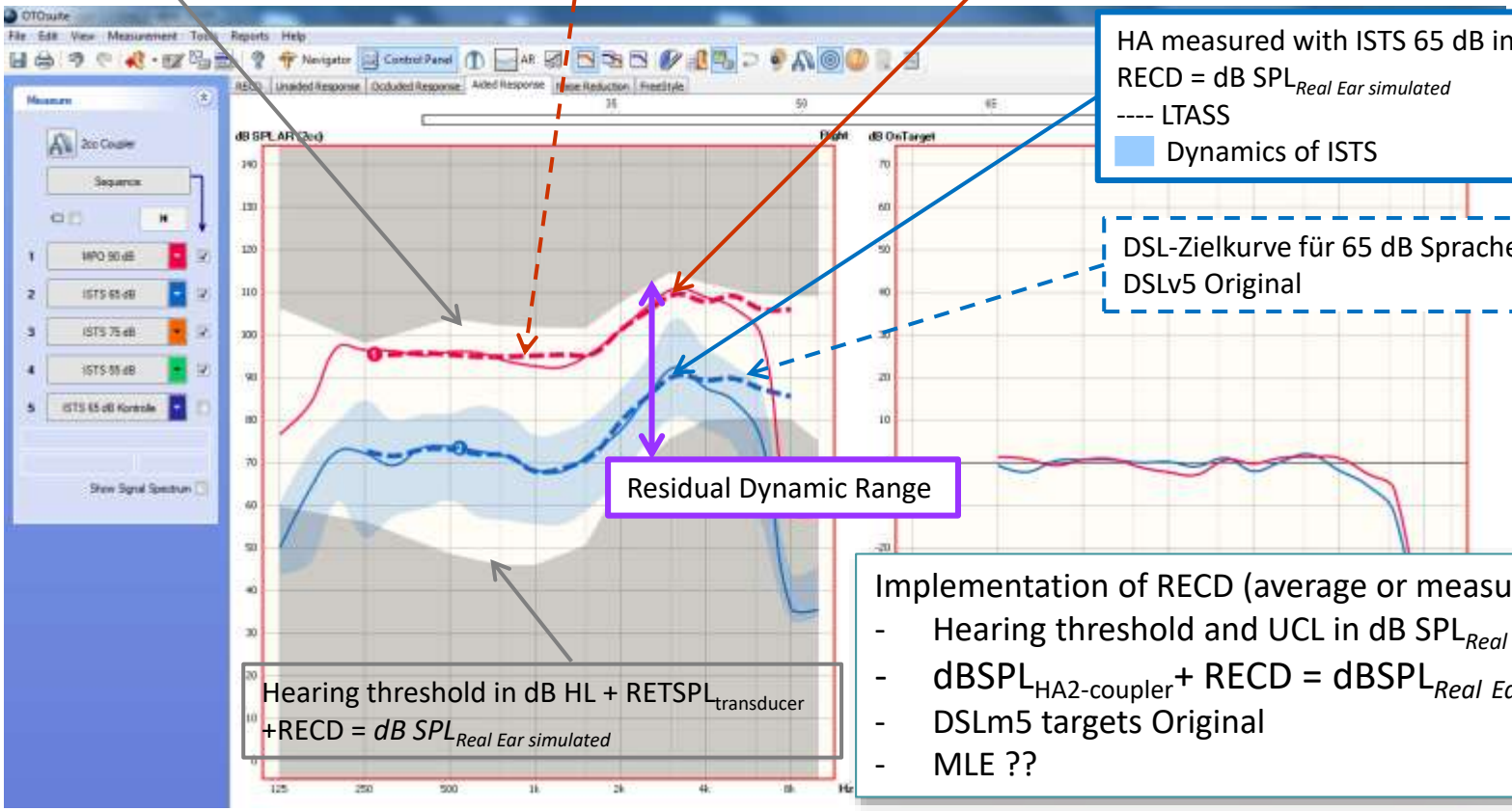
- Hearing threshold and UCL in dB $SPL_{Real\ Ear\ simulated}$
- $dBSPL_{HA4\text{-}coupler}$ + (W)RECD = dB $SPL_{Real\ Ear\ simulated}$
- DSLm5 Zielkurve Original
- MLE applied to the speaker signal

Aurical PMM: Display coupler based REAR

UCL estimated (Pascoe) in
dB SPL + RECD = dB $SPL_{Real\ Ear\ simul.}$

BOLT target for MPO
DSLv5 Original

MPO measured in
dB $SPL_{HA2\ coupler}$ + RECD



HA measured with ISTS 65 dB in dB $SPL_{HA2\text{-}coupler}$ + RECD = dB $SPL_{Real\ Ear\ simulated}$
---- LTASS
Dynamics of ISTS

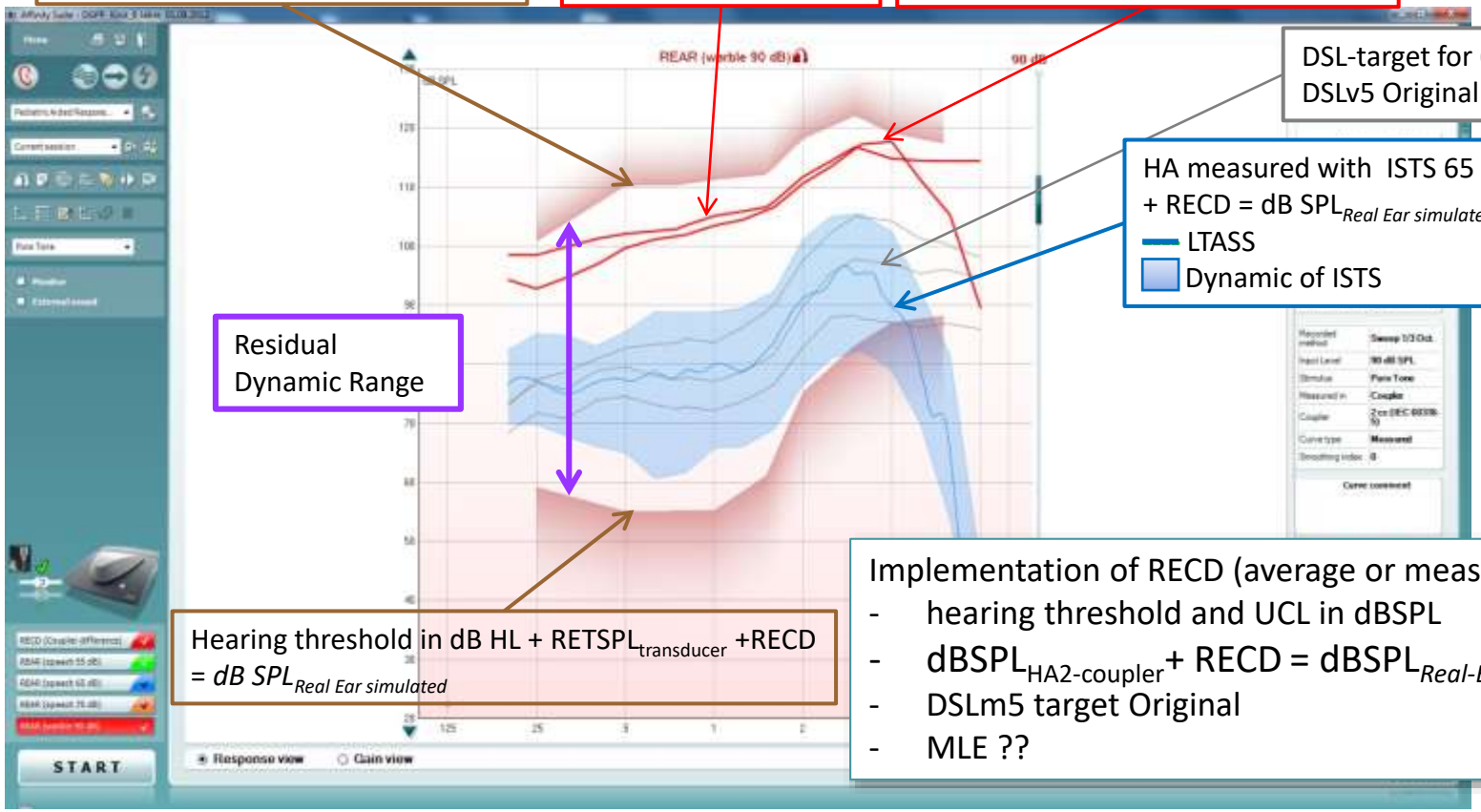
DSL-Zielkurve für 65 dB Sprache
DSLv5 Original

Residual Dynamic Range

Hearing threshold in dB HL + $RETSPL_{transducer}$ +RECD = *dB* $SPL_{Real\ Ear\ simulated}$

Implementation of RECD (average or measured):
- Hearing threshold and UCL in dB $SPL_{Real\ Ear\ simulated}$
- $dBSPL_{HA2\text{-}coupler}$+ RECD = $dBSPL_{Real\ Ear\ simulated}$
- DSLm5 targets Original
- MLE ??

Affinity2.0: Display coupler based REAR

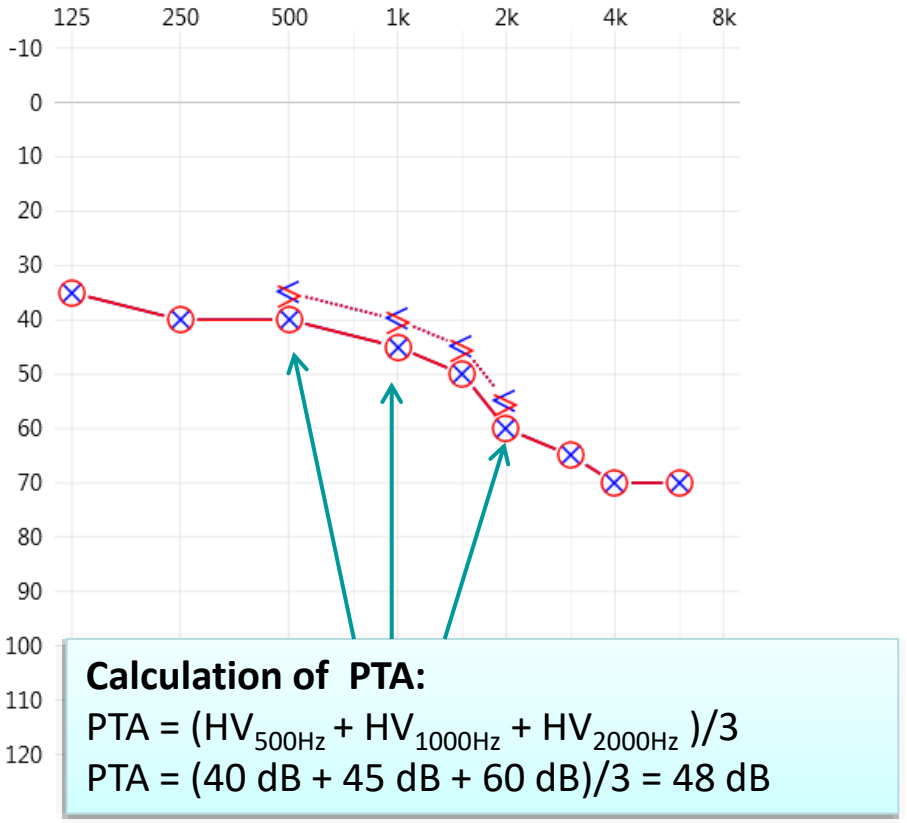


Case study for comparison of results

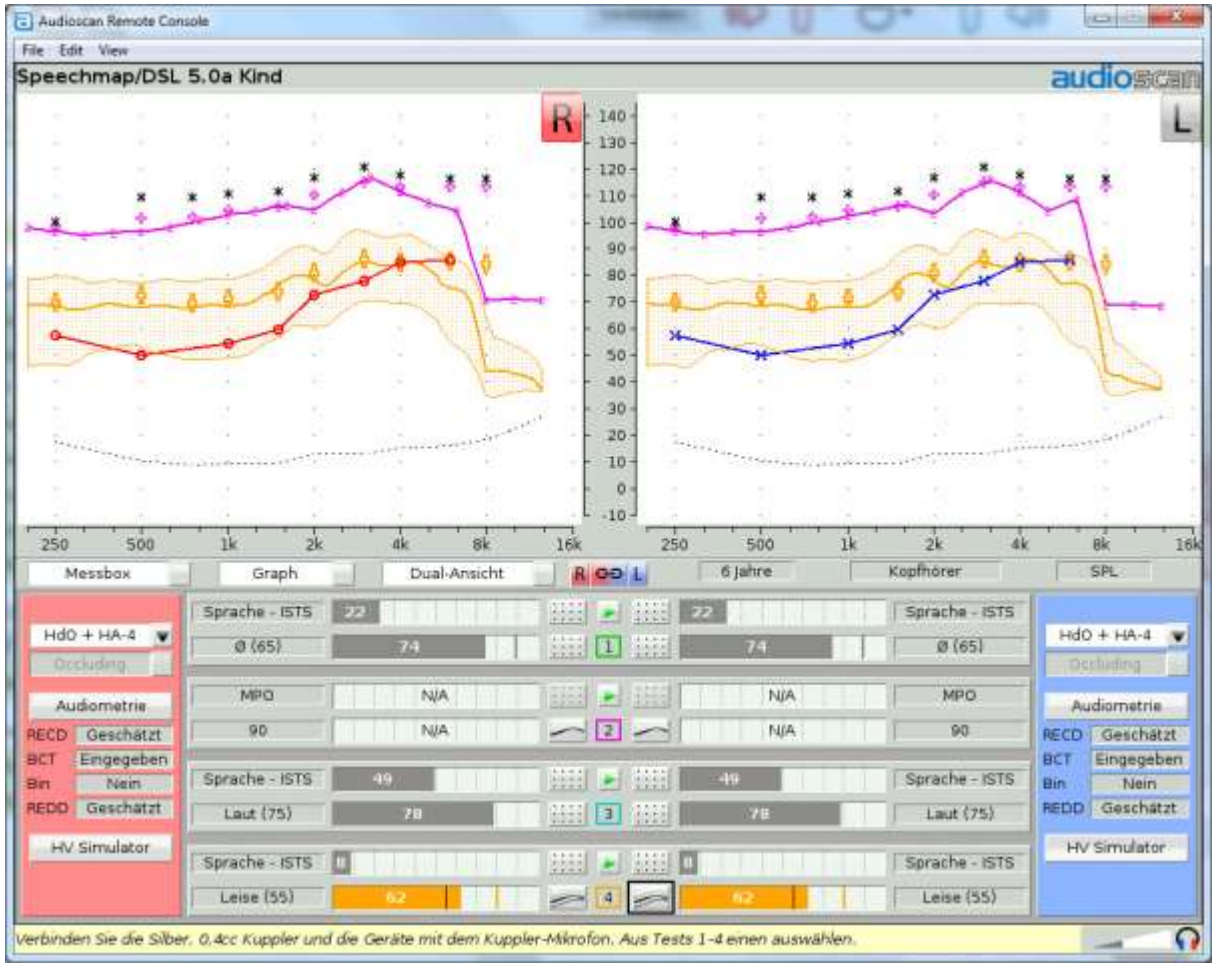
Affinity2.0, Aurical, Verifit2

Case Study: Comparison of REM equipment

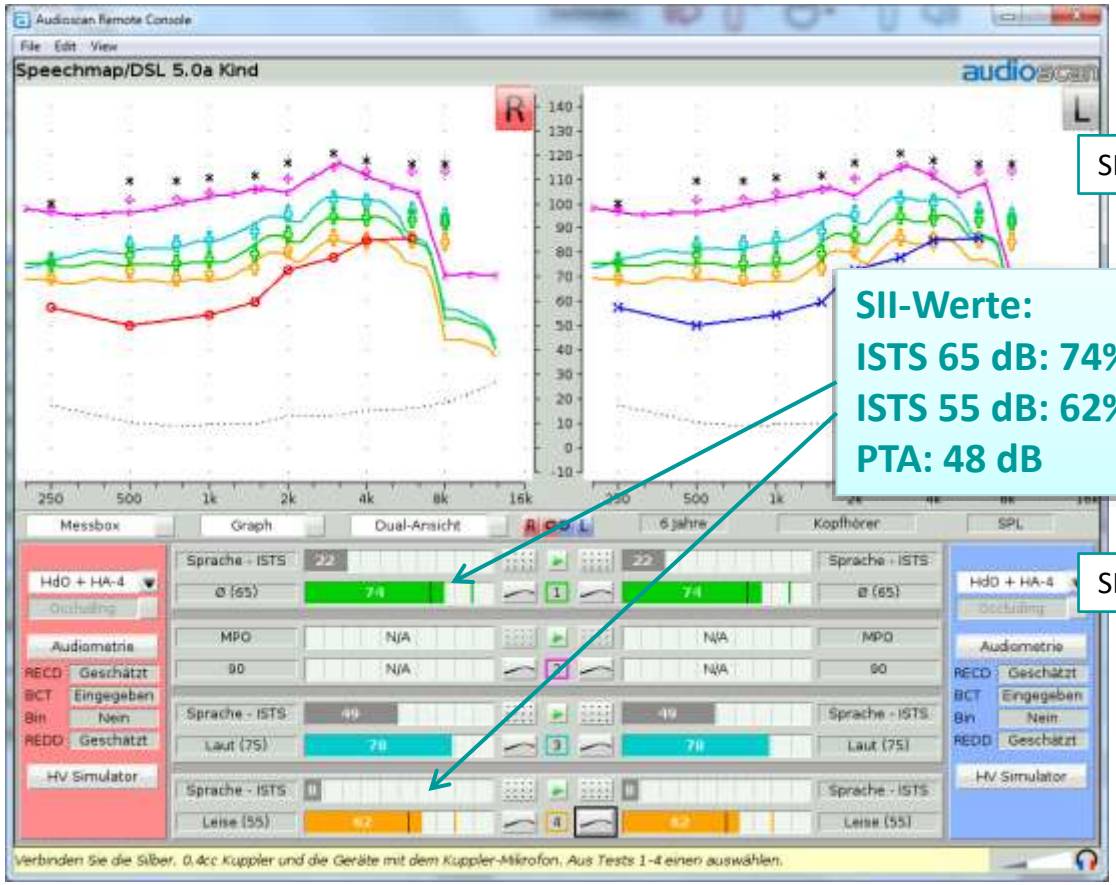
- Child 6 years old:
  - Audiometry with headphones
  - RECD age-related averages
  - BTE hearing aids
  - Closed earmold
  - DSLv5 child
  - HA fitted and fine tuned with Verifit (precondition for comparison)



First-Fit and Fine tuning with Verifit2 VF-2



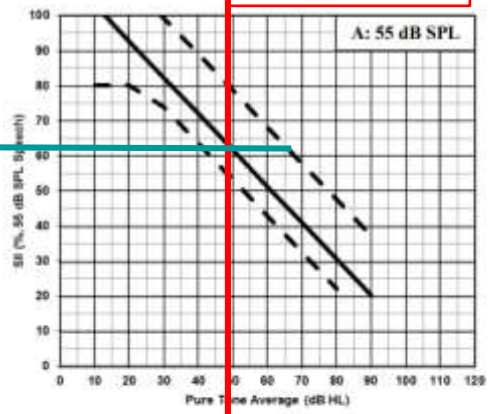
First Fit and Fine tuning with Verifit2 VF-2



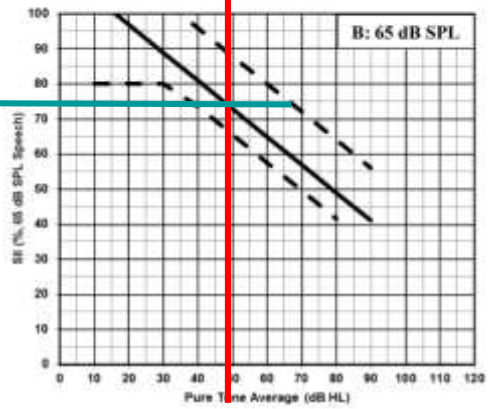
SII-Werte:
ISTS 65 dB: 74%
ISTS 55 dB: 62%
PTA: 48 dB

PTA: 48 dB HL

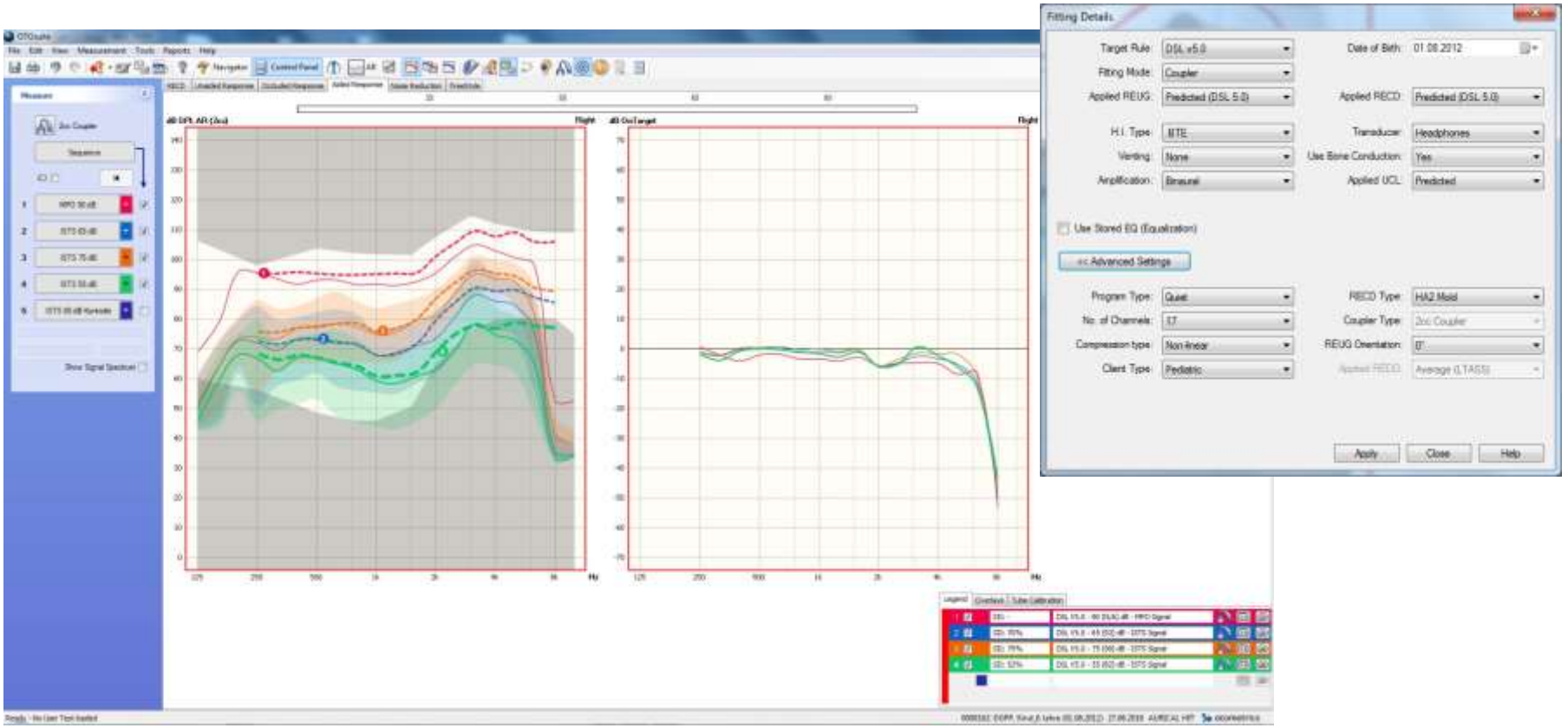
SII_{55dB} 62%



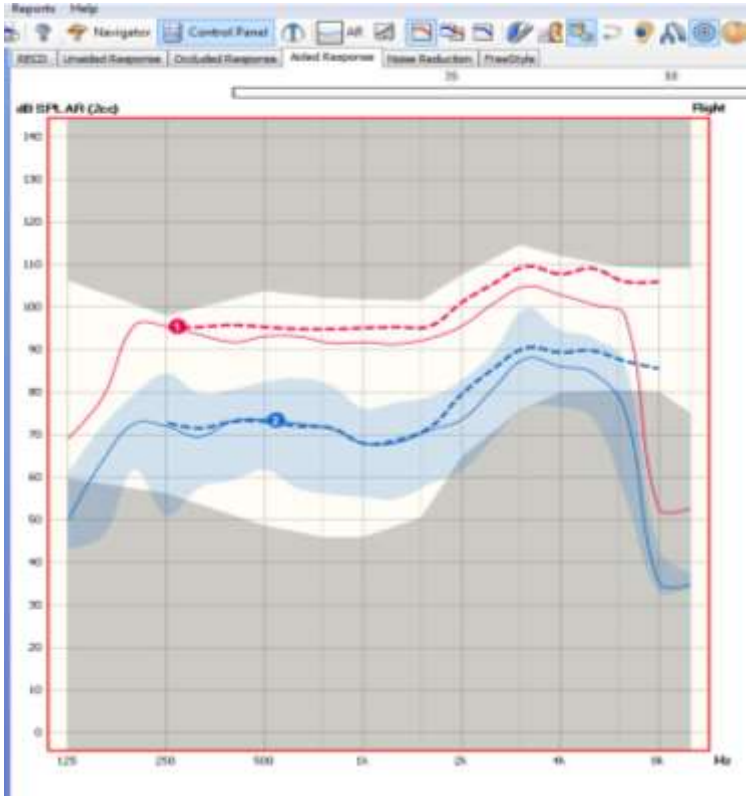
SII_{65dB} 74%



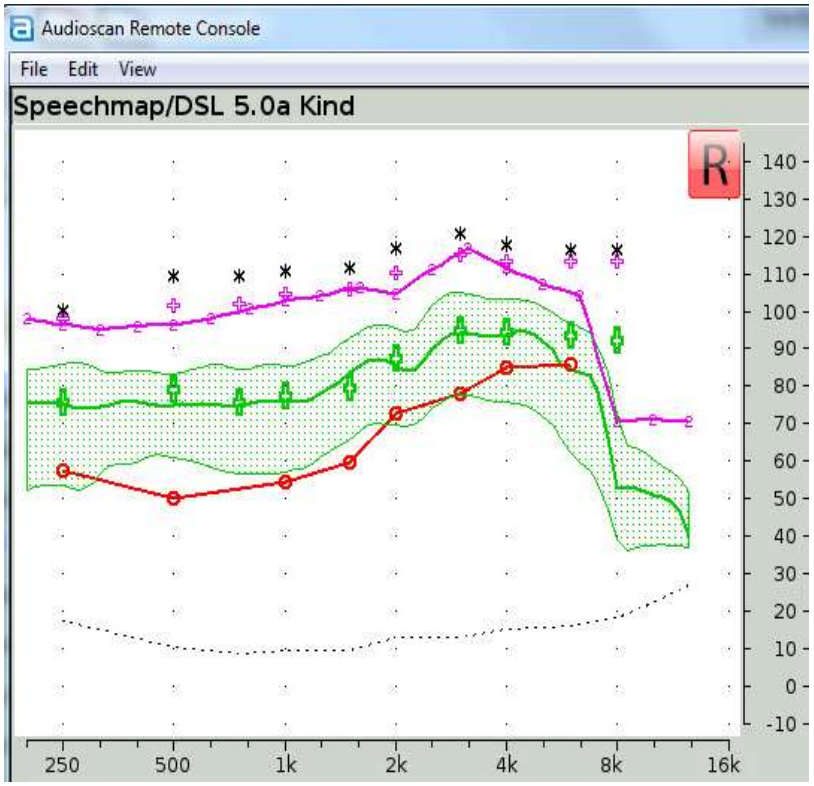
HA fitted with VF2 measured in Aurical



HA fitted with VF2 measured in Aurical

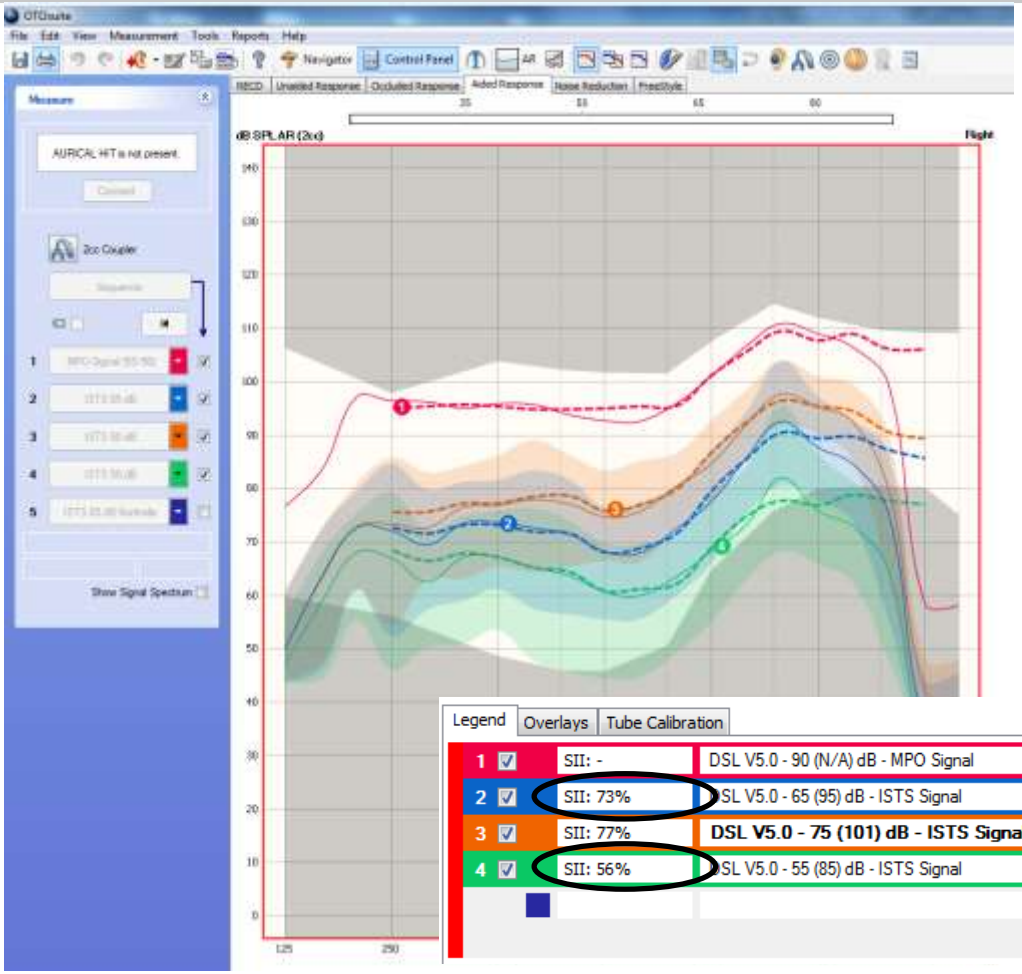


Verifit2 fit measured with Aurical
Otosuite Software Version 4.84.0.61



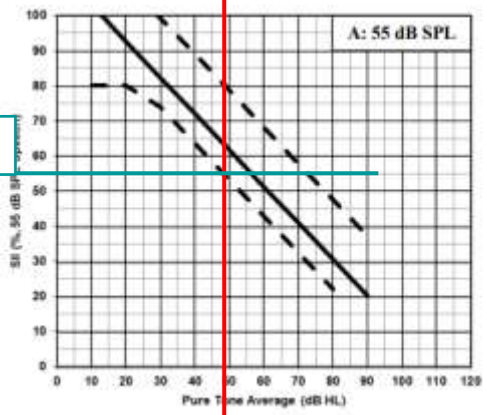
Verifit2 fit
Verifit2 Software Version 4.12.4

Fit & fine tuning to target in Aurical

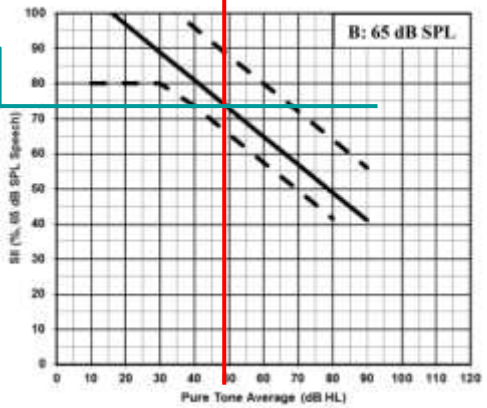


PTA = 48 dB HL

SII_{55dB} 56%

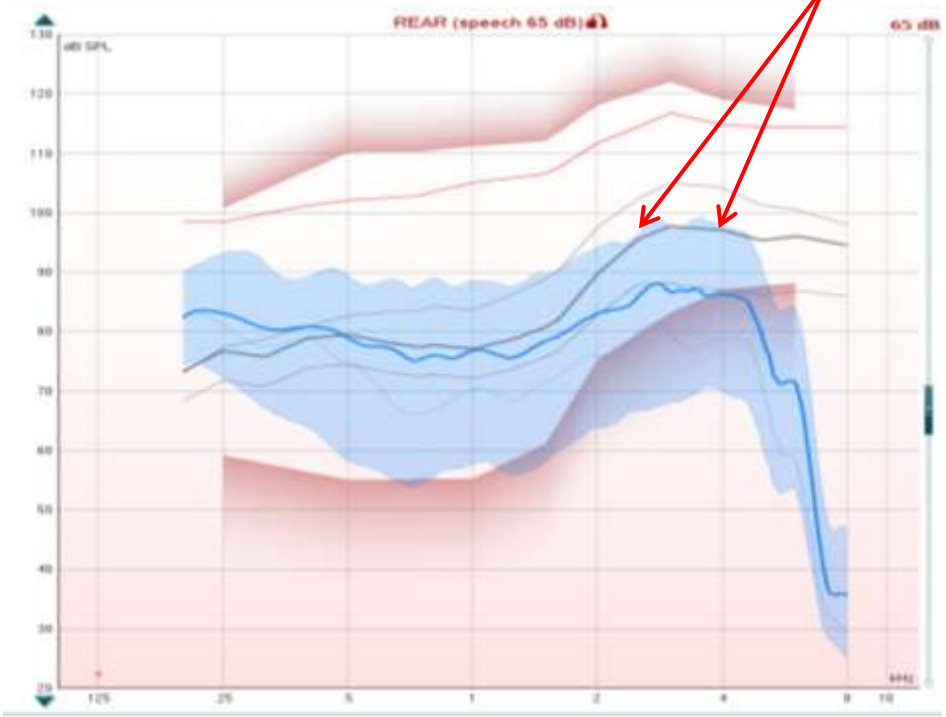


SII_{65dB} 73%

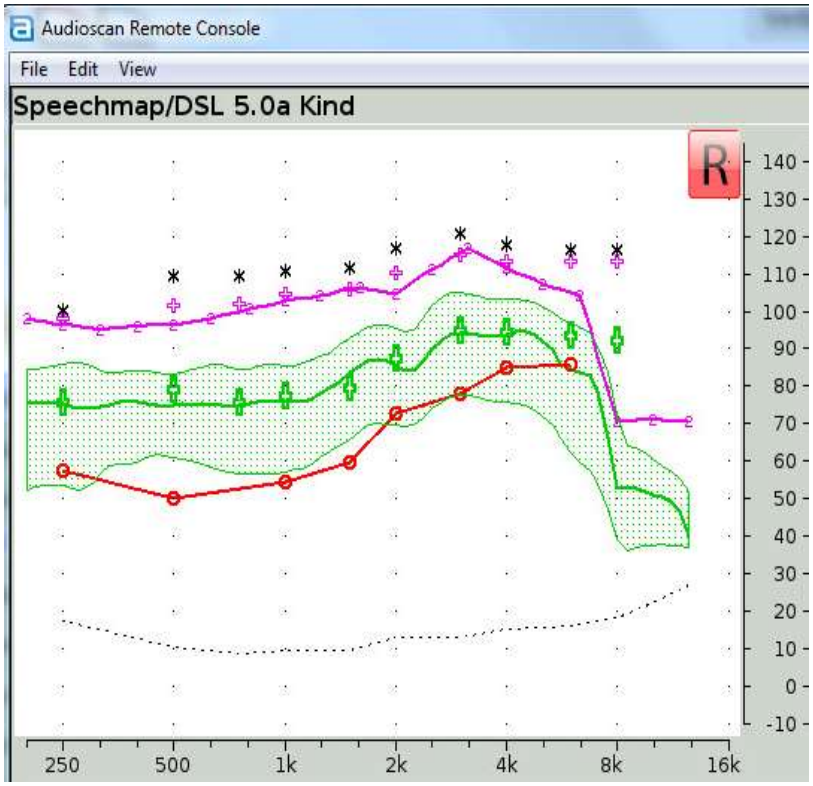


HA fitted with VF2 measured with Affinity

At 2-4 kHz around 7-10 dB are missing

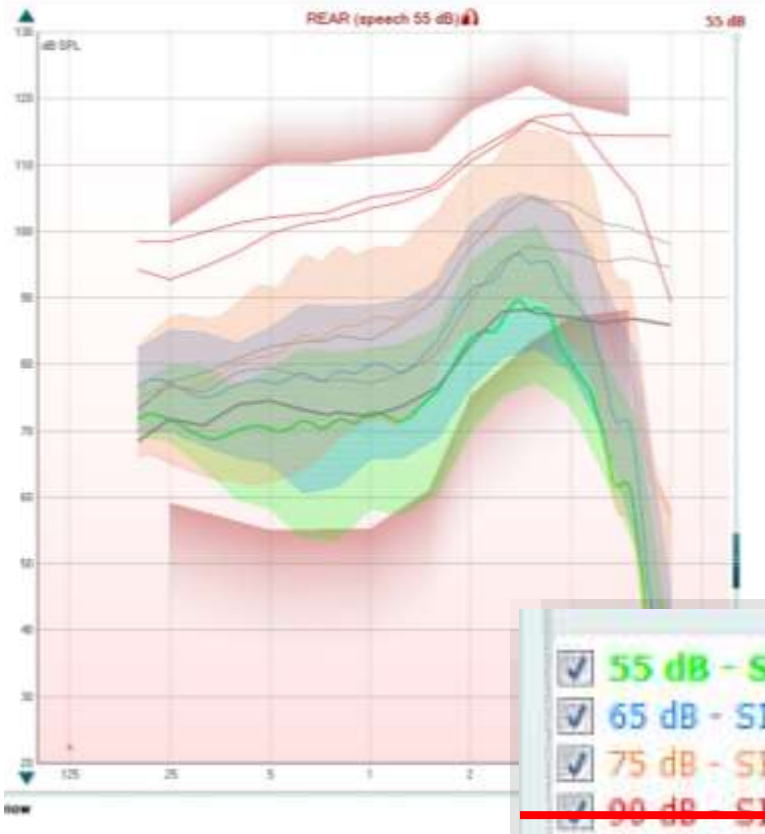


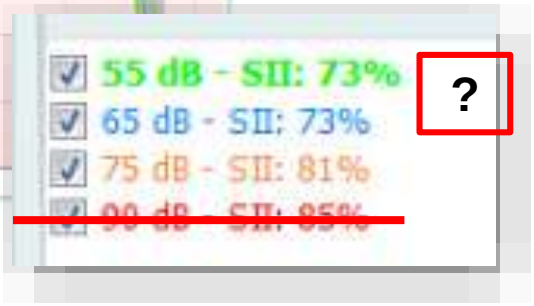
Verifit2 fit measured with Affinity
Affinity Suite Software Version 2.11.00



Verifit2 fit
Verifit2 Software Version 4.16.5

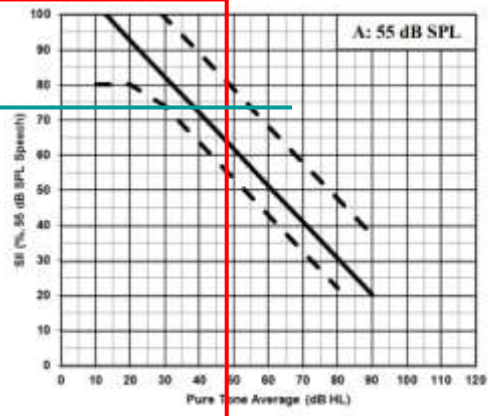
Fit and fine tuning with Affinity: SII



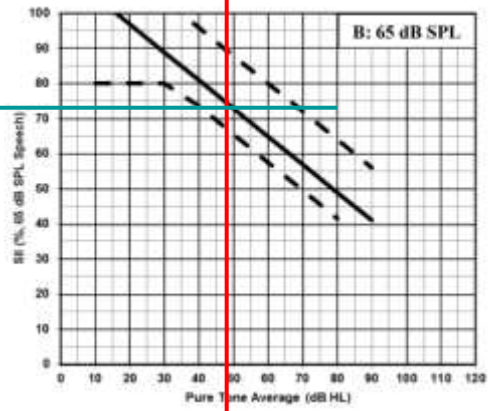


PTA = 48 dB HL

SII_{55dB} 73%

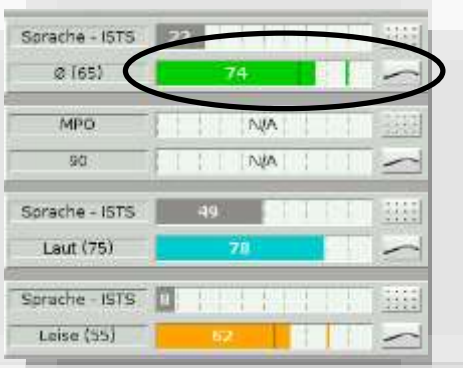


SII_{65dB} 73%

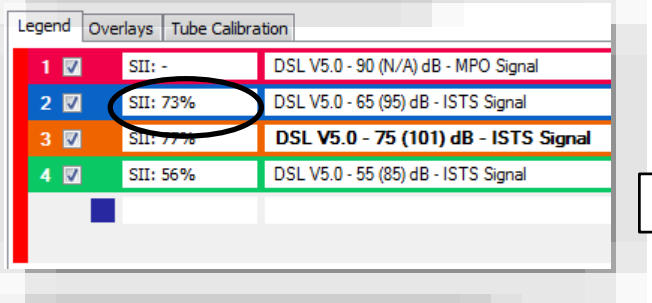


Comparison of SII values after Fine tuning

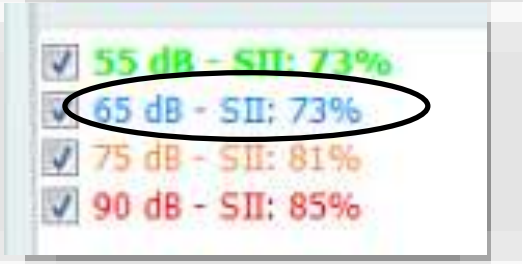
Verifit2 / Verifit 1



Aurical / Calisto

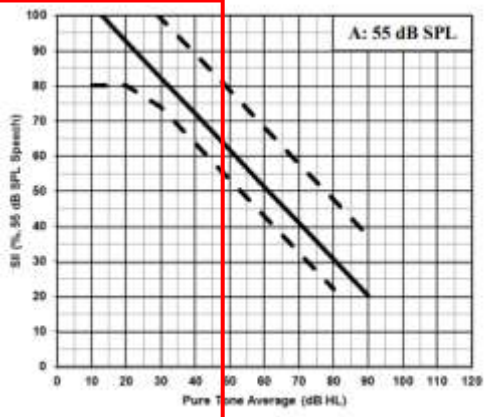


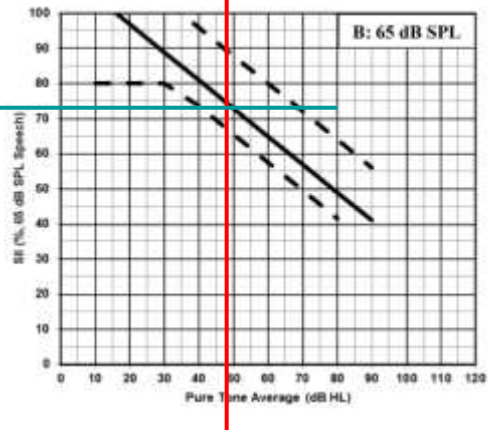
Affinity / Equinox



SII_{65dB} 73%/74%

PTA = 48 dB HL





Comparison of SII values after Fine tuning

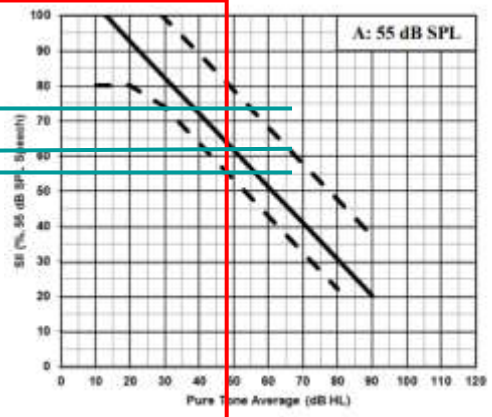
Verifit2 / Verifit 1

SII_{55dB} 62%

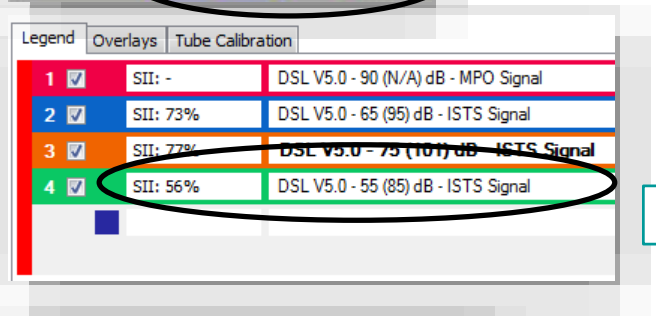
SII_{55dB} 73%

SII_{55dB} 56%

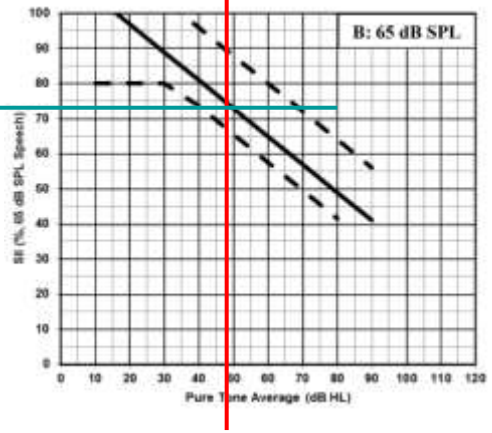
PTA = 48 dB HL



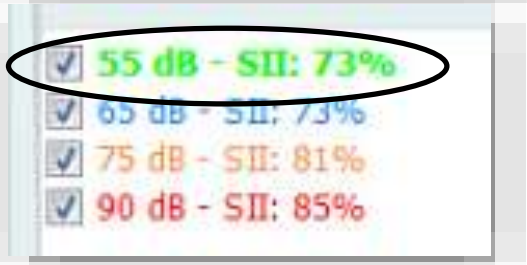
Aurical / Calisto



SII_{65dB} 73%/74%



Affinity / Equinox



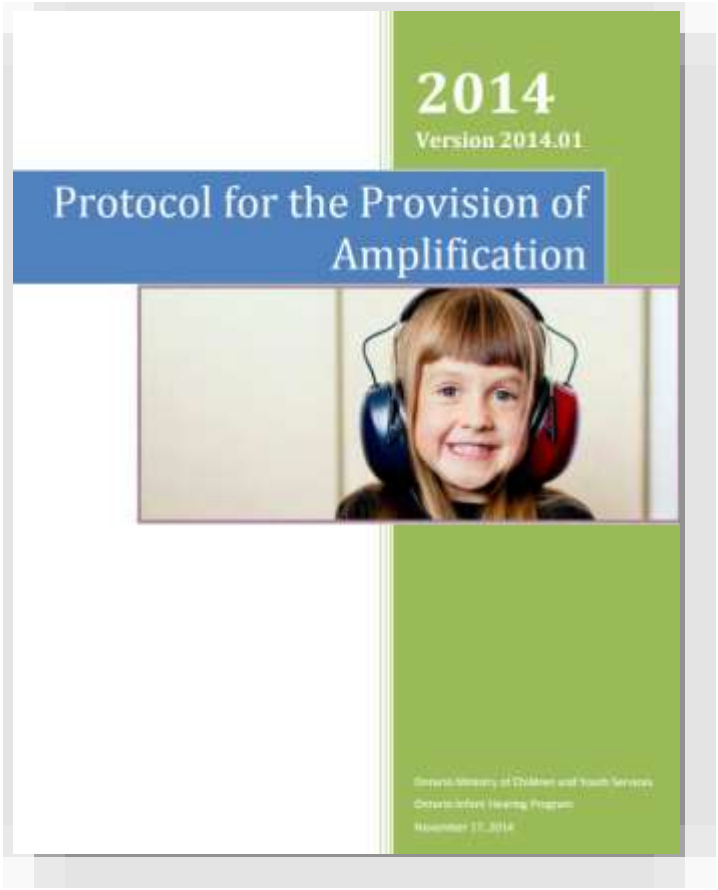
Maximum Audible Output Frequency Range

MAOF

Verification of Frequency Lowering

- Guideline for Pediatric Fitting
  - UWO, Kanda 2014

- Use of Frequency Lowering & Verification
  - Check & verify audibility for fricatives
  - Guidance
    - Signals: UWO /s/ & /sh/
    - Addendum 2, page 44-62

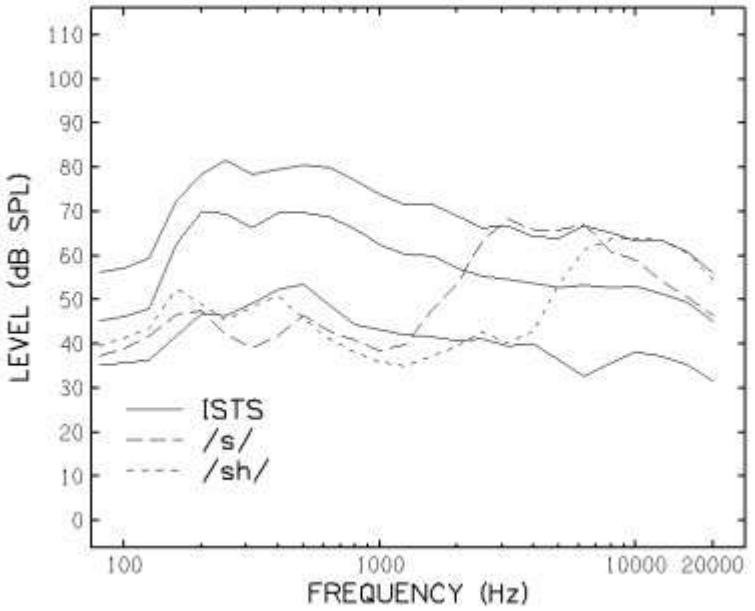


University of Western Ontario, Susan Scollie et al.: Ontario Infant Hearing Program OIHP

Quelle: www.dslio.com

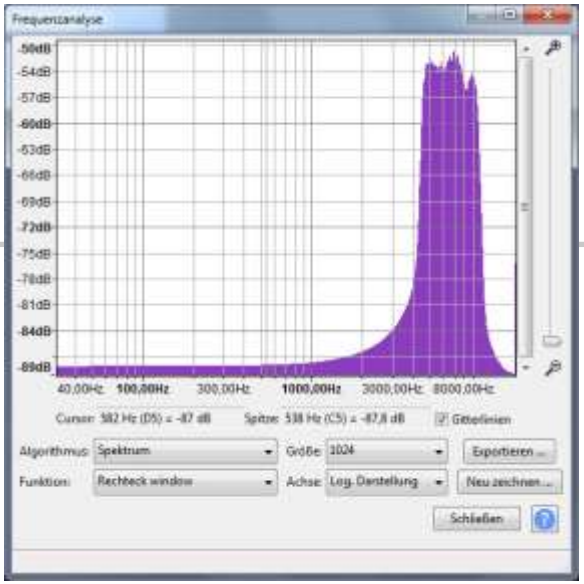
Signals for Verification: /s/ & /sh/

- Frequency specific speech signals
- Extracted from ISTS
- Filtered and adapted
  - for better differentiation
  - adapted to level in speech
    - /s-10dB/ and /sh-6dB/ when selecting 65 dB speech level

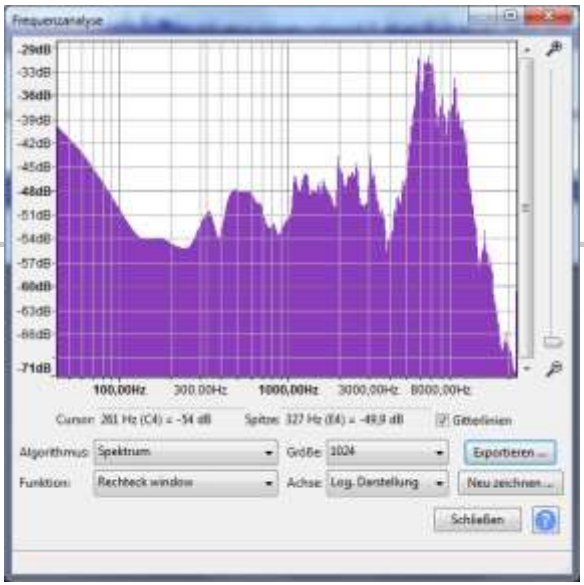


Spectrum of the ISTS at 65 dB and LTASS from UWO /s/ and /sh/

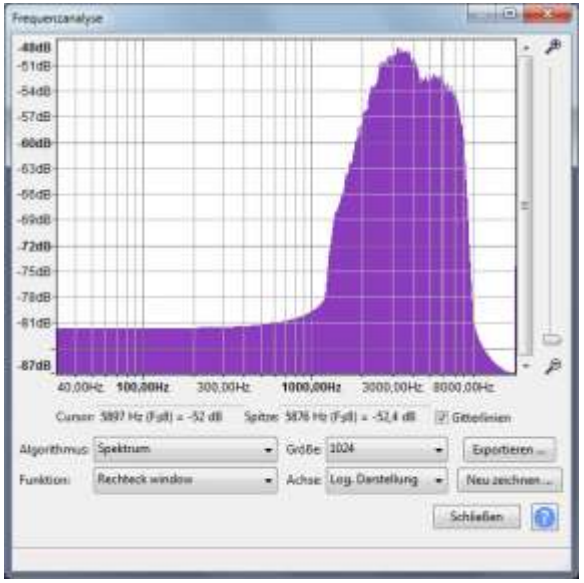
Abb. Quelle: Ontario Infant Hearing Program (2014.1), www.dslio.com



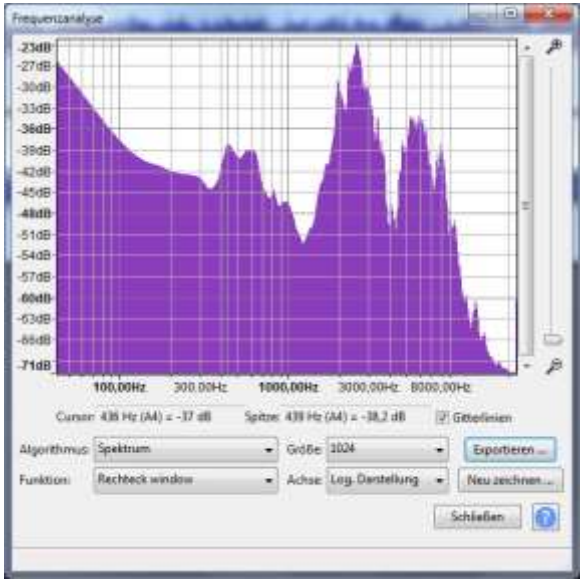
UWO_s



Ling_s



UWO_sh

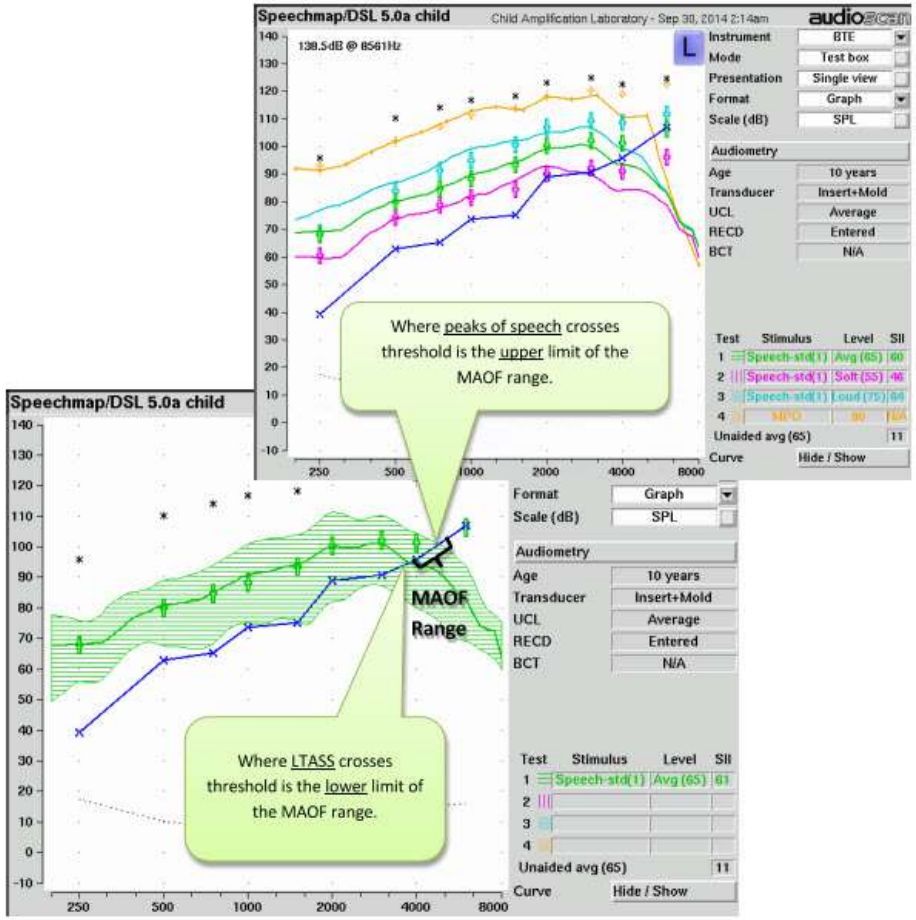


Ling_sh

Determination of MAOF range

in measurement results from ISTS 65 dB without Frequency Lowering

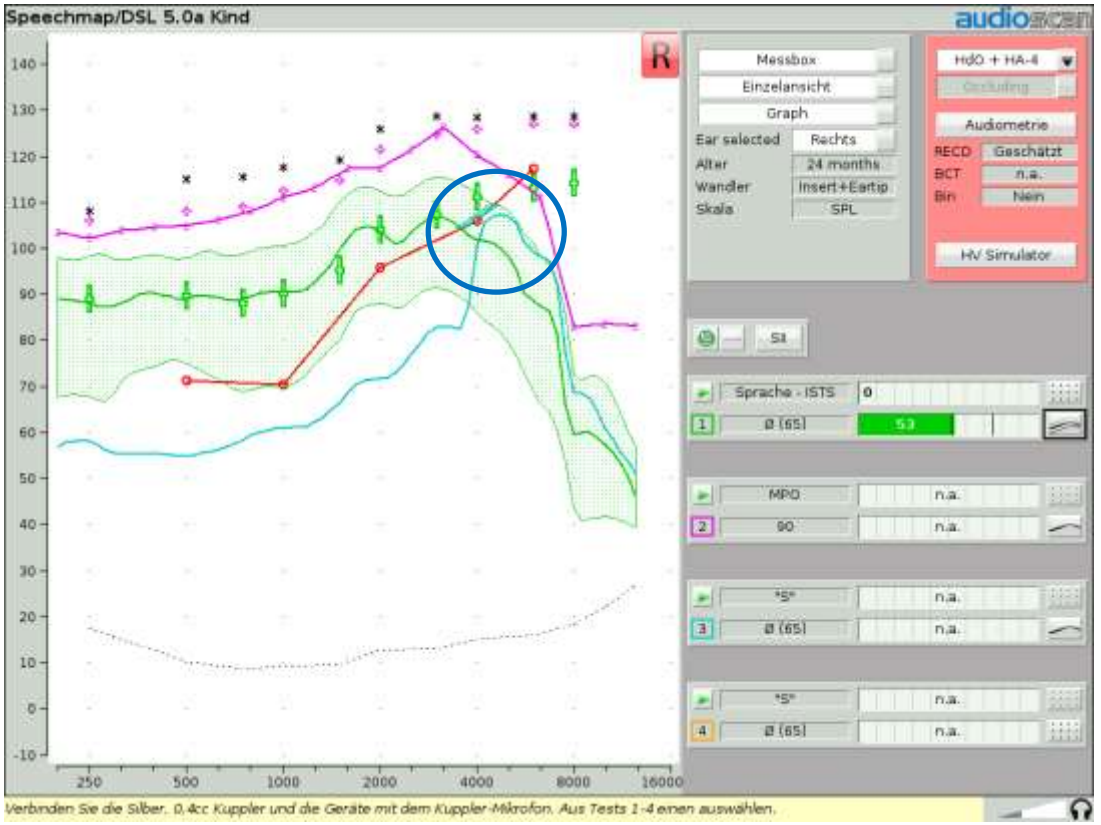
- Fitting & fine tuning to DSLm5[child]
  - Without FL activated
- Determination of MAOF range:
  - Dynamic range of ISTS 65 dB
    - intersection between LTASS and HTL
    - intersection between 99th percentile and HTL



MAOF in Verifit2:

check audibility of /s/ without Frequency Lowering activated

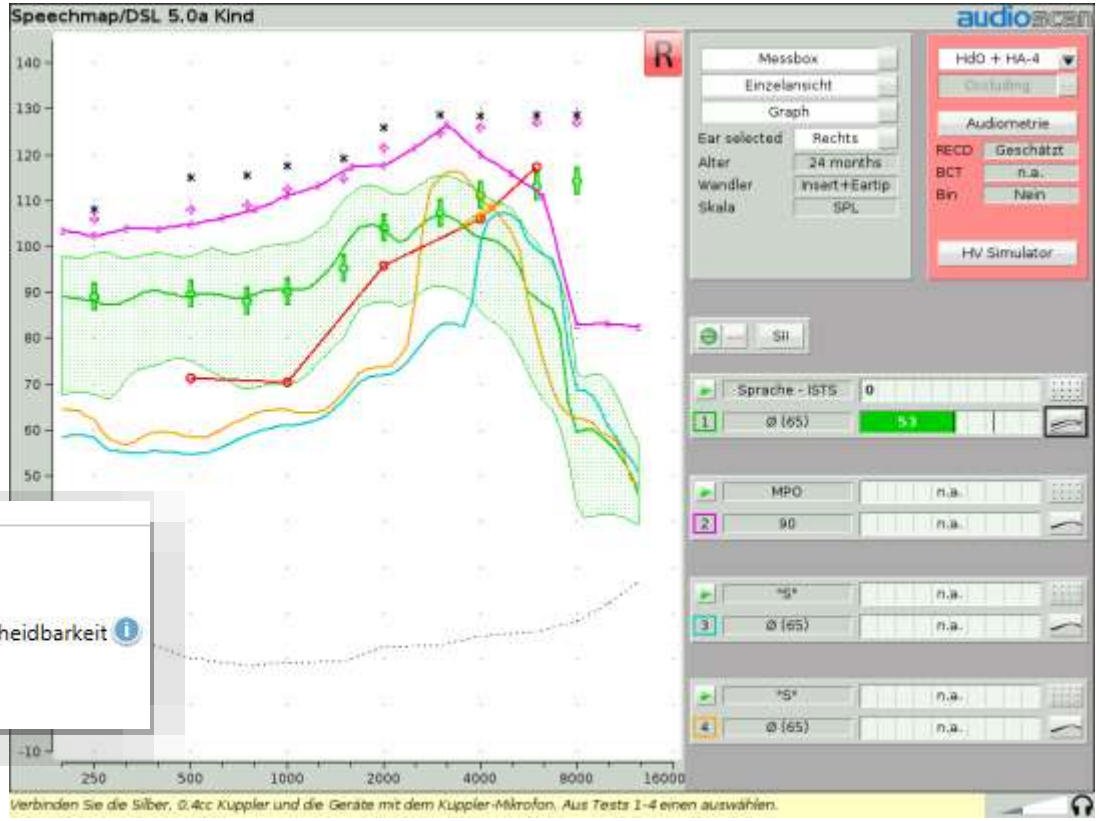
- Preconditions:
  - ISTS 65 dB result optimized
  - Select /s/ for next test
- Display MAOF-range in VF2
  - Select /s/
  - Select view “MAOF”
  - Record measurement



Result:
/s/ is below MAOF-range and may in normal speech not be audible

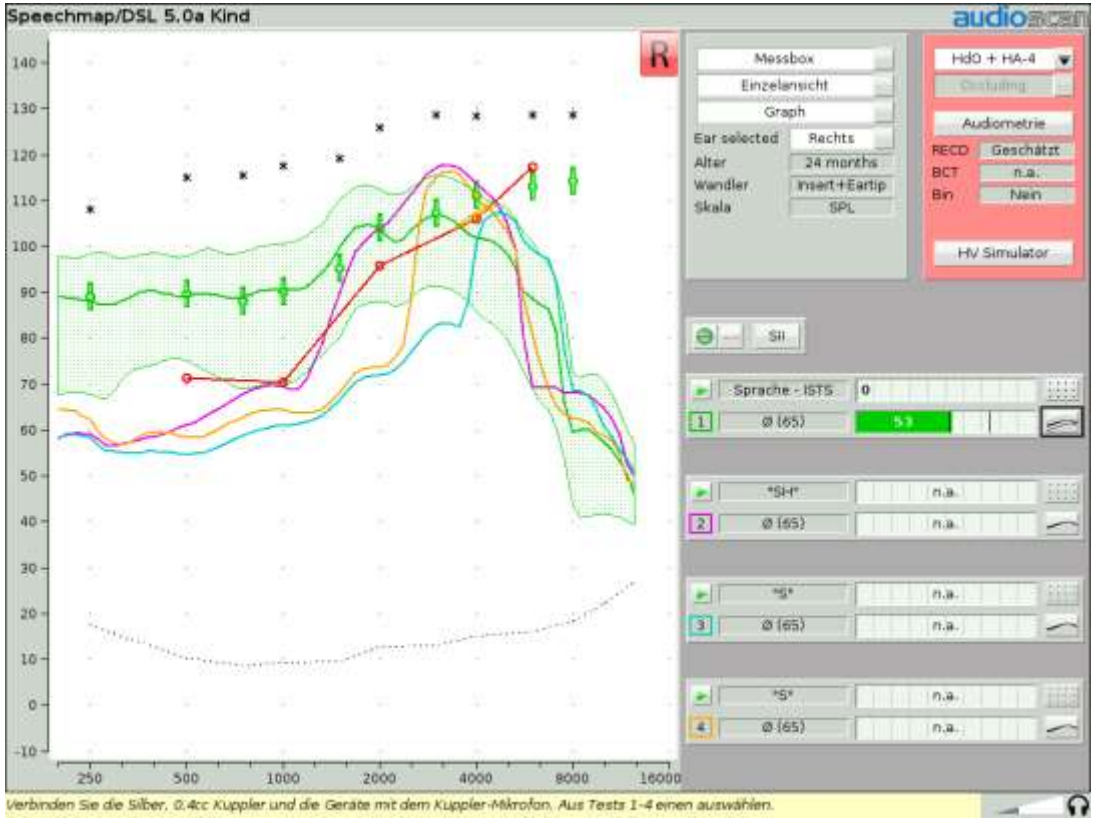
MAOF in Verifit2: Fit Frequency Lowering

- Fit & Finetune
  - Activate frequency lowering
  - Select /s/ for further test
  - Move the output for /s/ into MAOF range by help of frequency lowering
  - Back shoulder of /s/ should be placed in the MAOF range

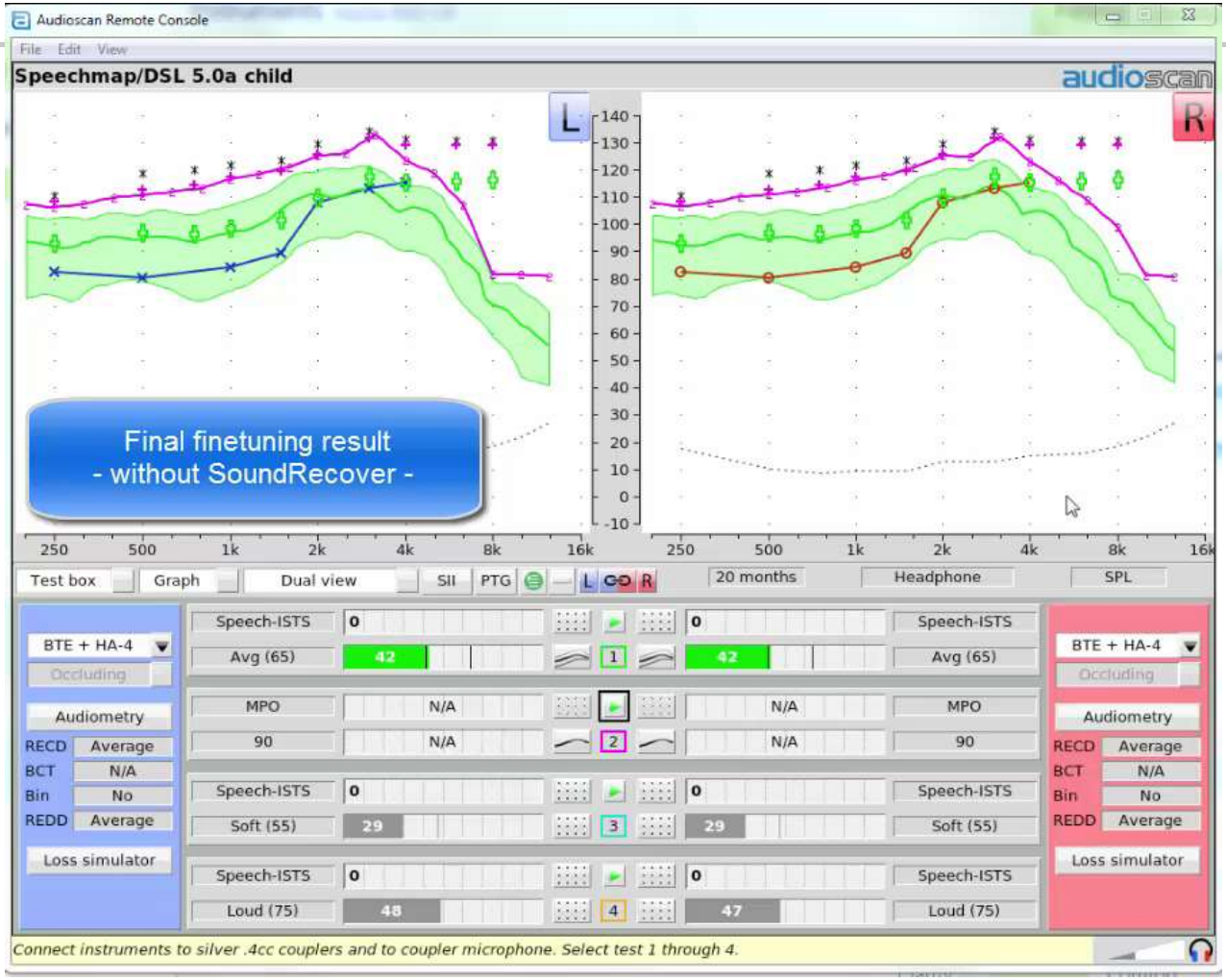


MAOF in Verifit2: optimize Frequency Lowering

- Optimize FL:
  - Measure /sh/
  - /sh/ and /s/ must show clear deviation
  - If necessary reduce /s/ in clarity to ensure differentiation
  - Find a balance between utmost audibility and speech distortion
- Efficacy needs to be validated
  - Phoneme Perception Test



Verification with MAOF (Video)



Conclusions

- Measure RECD is "*Best practice in HA fitting for children*", monitor quality of RECD outcome and the consequences on target match in verification
- Verify fitting with simulated REAR in test box
  - Minor deviations from target in certain frequencies are natural
  - Monitor deviations from target match in high frequencies in relation to earmold quality and feedback issues
  - SII Normative Values can help to assess own verification results in comparison to standards
  - Average RECD is based on statics → it is expected, that individual values deviate dependent on frequency
  - Import RECD values to fitting software → ease of recalculation for changes

Measure & verify regularly to monitor and adapt for consistent audibility!

Thank you for listening!

Questions? Discussion?