# NCRAR Workshop

# Ototoxicity Early Identification & Monitoring

VA Rehabilitation Research & Development
National Center for Rehabilitative Auditory Research

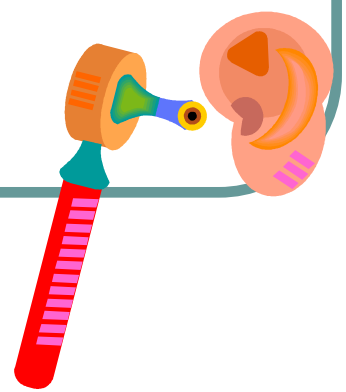

Site by CDR Marketing Group

# Outline

I. Learner Outcomes
II. Overview: Basic Principles
III. Tinnitus Monitoring
IV. Ototoxicity Monitoring in Adults
V. Objective Monitoring
VI. Ototoxicity Monitoring in Children
VII. Establishing Program

# IV. Monitoring Hearing in Adults

Kelly M. Reavis, M.S., CCC-A



VA RR&D
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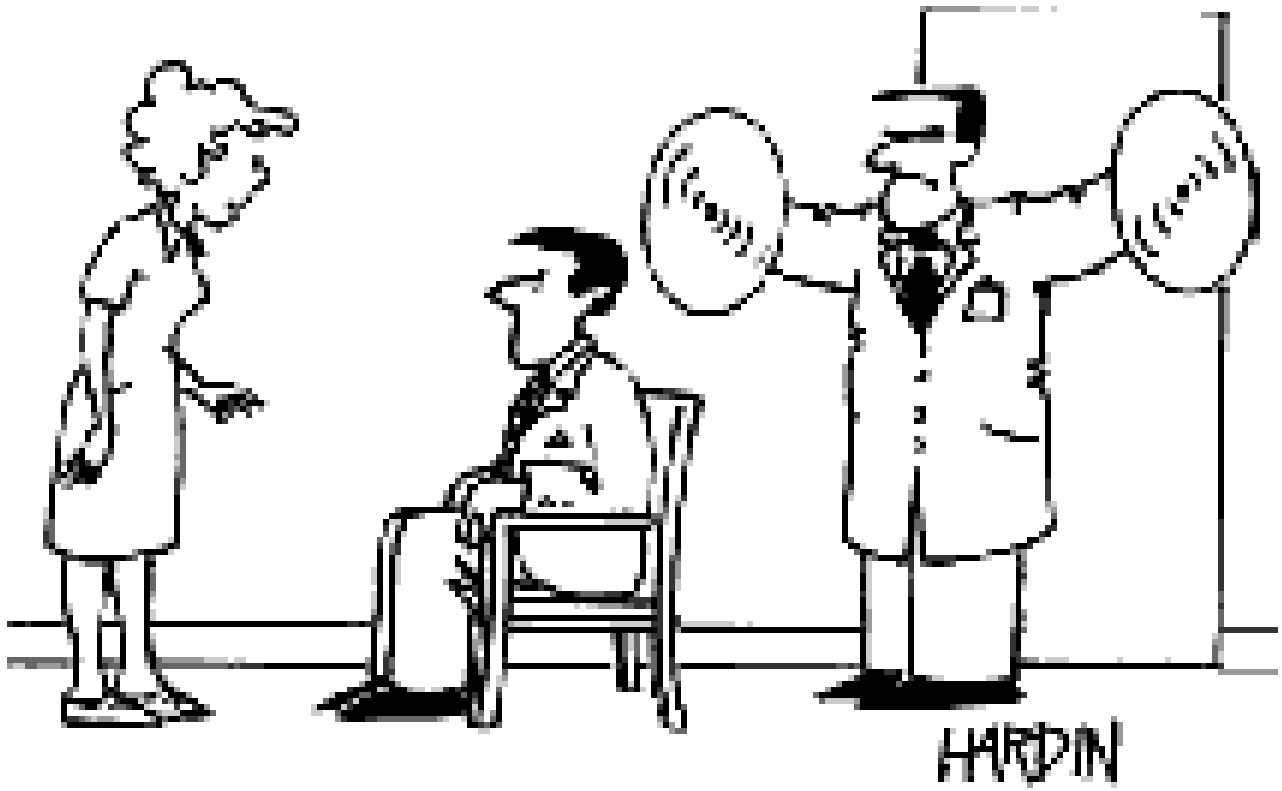



"Now just relax and we'll begin your hearing test."

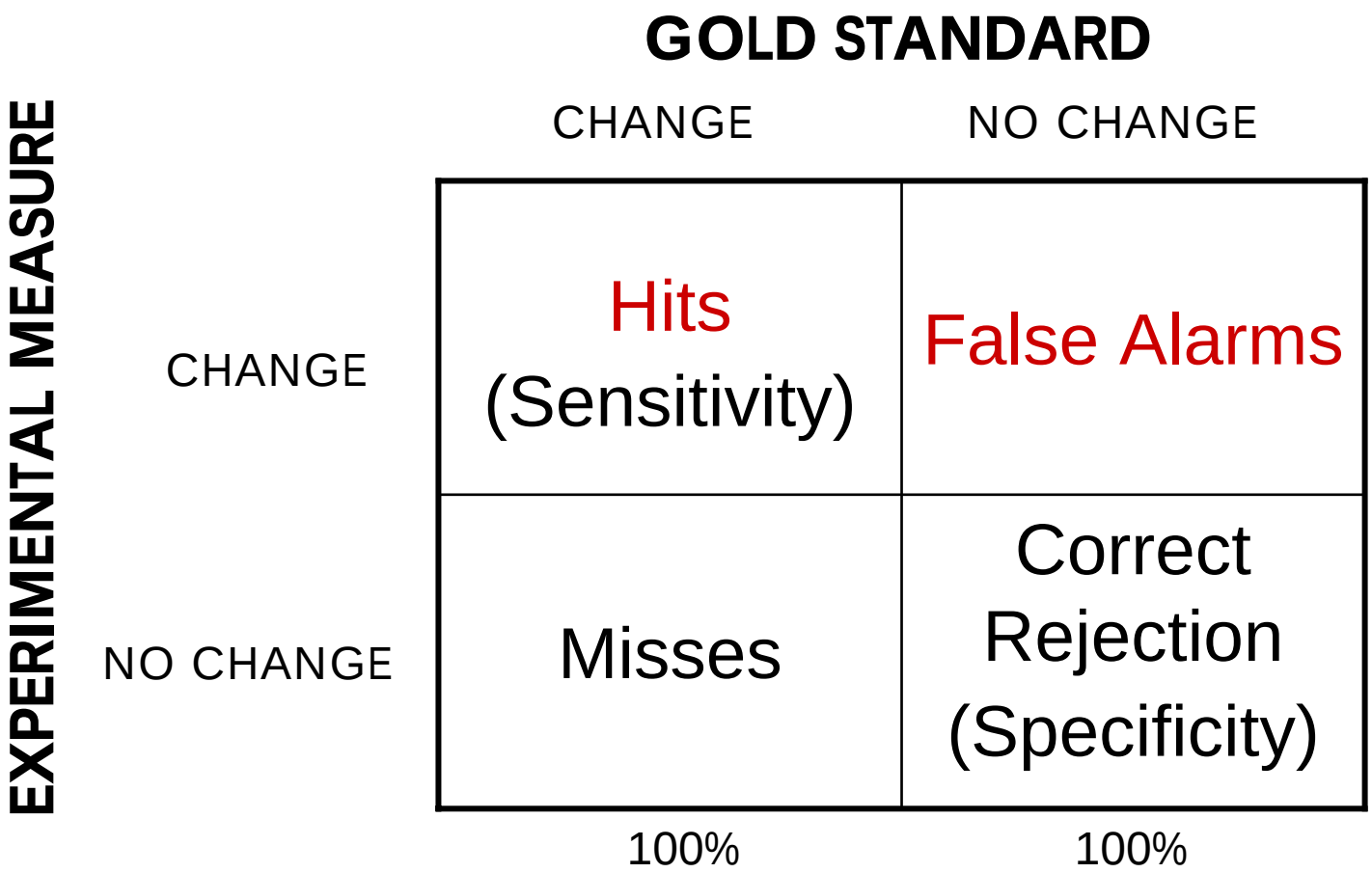
# Test Characteristics

- Sensitivity & Specificity
  - (high hit rate & low false positive rate)
- Reliability (test-retest)
- Time efficiency

# Sensitivity & Specificity

- Sensitivity (hit rate)
  - Percentage of times ears with hearing change identified as having hearing change by the experimental measure
  - 100% - sensitivity = false negative or miss rate
- Specificity (correct rejection rate)
  - Percentage of times ears with no hearing change are correctly labeled as no change by the experimental measure
  - 100% - specificity = false positive or false alarm rate

# Sensitivity & Specificity



# Reliability & Time Efficiency

- Reliability (test-retest)
  - Determine size change (e.g., in pure-tone threshold or OAE amplitude) likely to be real and not random variability
  - Significantly different change with 0.05 level of confidence provides 95% probability that change is real
- Time Efficiency (clinically practical)

# Monitoring Principles

- High- to low-  frequency progression
- High-frequency testing is reliable (Fausti et al., 1998; Frank, 1990; Frank & Driesbach, 1991; Gordon et al., under review)
- Studies have shown the efficacy of high-frequency monitoring (Dreschler et al., 1989; Fausti  et al. 1984; Jacobson et al., 1969; Ress et al., 1999; Tange et al., 1985; Van der Hulst et al., 1988; Fausti et al., 1993; Fausti et al., 1994 )
- Studies have shown testing in 1/6-octave intervals provides earlier detection (Fausti et al., 2003; Vaughan et al., 2003)
- Individualized protocols targeting the *highest frequencies* a person can hear

# Keep in Mind

- There are no normative high-frequency sensitivity (i.e., threshold) standards due to lack of standardization in
  - calibration,
  - instrumentation,
  - and methodological procedures

Fausti SA, Frey RH, Rappaport BZ, Schechter MA. High-frequency audiometry with an earphone transducer. Sem Hear 1985;6:347-357

# Keep in Mind

- There is also a high degree of inter-subject threshold variability in high frequency sensitivity
  - Threshold variability increases with age (in elderly) and with higher test frequencies

Schechter MA, Fausti SA, Rappaport BZ, Frey RH. Age categorization of high-frequency auditory threshold data. J Acoust Soc Am 1986;79:767-771.

Matthews LJ, Lee FS, Mills JH, Dubno JR. Extended high-frequency thresholds in older adults. J Speech Lang Hear Res 1997;40:208-214.

# Does it Matter for Monitoring?

- However, the key to serial monitoring is intrasubject reliability
- High-frequency test-retest threshold variability is within a clinically acceptable range ($\pm$ 10 dB)
- As a result, monitoring near individual's high-frequency hearing limit is effective

# ASHA Change Criteria

≥ 20 dB change at 1 test frequency

≥ 10 dB change at 2 adjacent test frequencies

Loss of response at 3 consecutive test frequencies where responses were previously obtained

*Change confirmed by retest

# ASHA Change Criteria

- Normal variability in pure-tone thresholds occurs at random frequencies
- Threshold shifts at adjacent test frequencies indicate more systematic change (Atherly, 1963; Dobie, 1983)
  - Notion of examining threshold shift across frequencies
- Threshold shifts on repeated tests are also a stronger indication of a true threshold change (Royster & Royster, 1982)

# *1/6th Octave Testing Provides Earlier Detection*

# 1/2 Octave vs. 1/6 Octave

| 1/2 Octave Protocol | |
|---|---|
| Test Frequency (kHz) | Change From Baseline |
| ≤ 8 | 0 |
| 11.2 | +10 |
| 16 | 5 |

| 1/6 Octave Protocol | |
|---|---|
| Test Frequency (kHz) | Change From Baseline |
| ≤ 8 | 0 |
| 9 | 5 |
| 10 | 5 |
| 11.2 | +10 |
| 12.5 | +10 |
| 14 | +10 |
| 16 | 5 |

# 1/2 Octave vs. 1/6 Octave

| 1/2 Octave Protocol | |
|---|---|
| Test Frequency (kHz) | Change From Baseline |
| 1 | 0 |
| 1.5 | 0 |
| 2 | 0 |
| 3 | 0 |
| 4 | 0 |
| 6 | 5 |
| 8 | +10 |

| 1/6 Octave Protocol | |
|---|---|
| Test Frequency (kHz) | Change From Baseline |
| 1 | 0 |
| 1 | 0 |
| 2 | 0 |
| 3 | 0 |
| 4 | 5 |
| 6 | 5 |
| 6.35 | +10 |
| 7.13 | +15 |
| 8.00 | +10 |

# 1/6th-Octave vs Conventional

| | AMG (N=25 ears) | Cisplatin or Carboplatin (N=185 ears) |
|---|---|---|
| **Percentage of Ears Missed or Detected Later** | 28% | 37% |

Compared to testing in 1/6th-octave steps above and below 8 kHz, testing conventional frequencies alone resulted in initial ototoxic hearing change missed or detected later in 76/210 ears

Number of Frequencies between 2 – 20 kHz in 1/6 Octave steps?

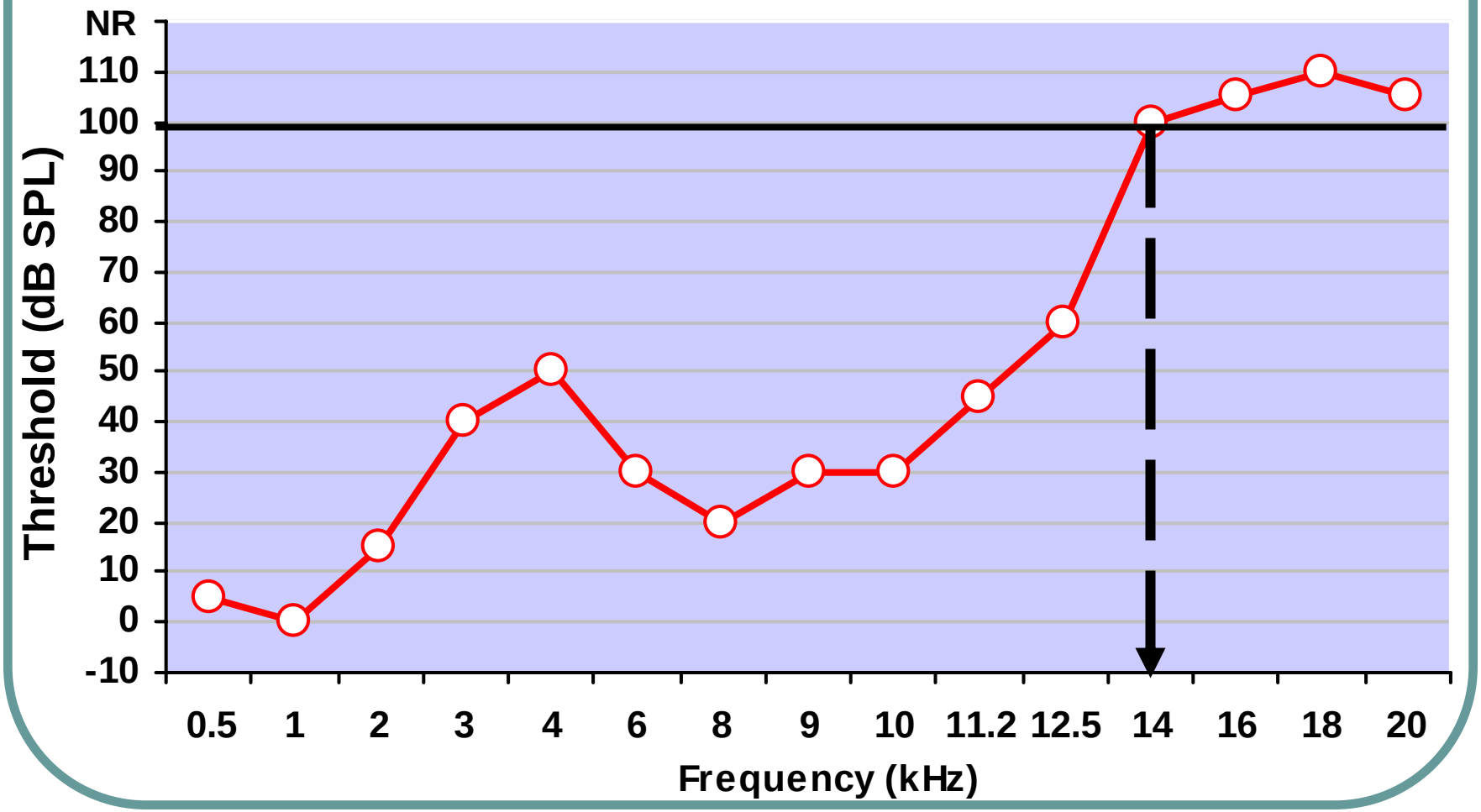
……25 Test Frequencies x 2 ears =

50 Test Frequencies

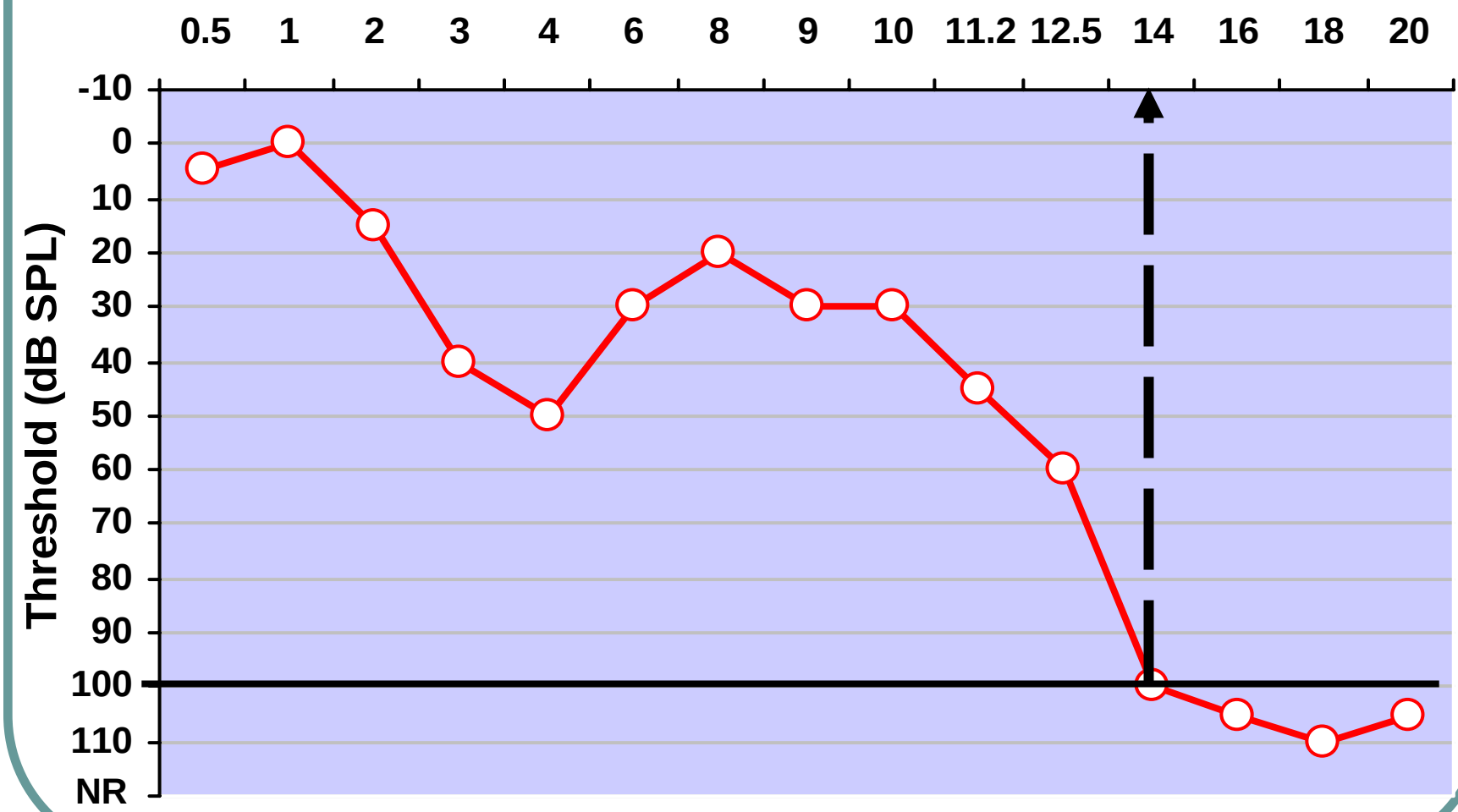
OUCH!

# *Individualized Sensitive Range for Ototoxicity (SRO)*

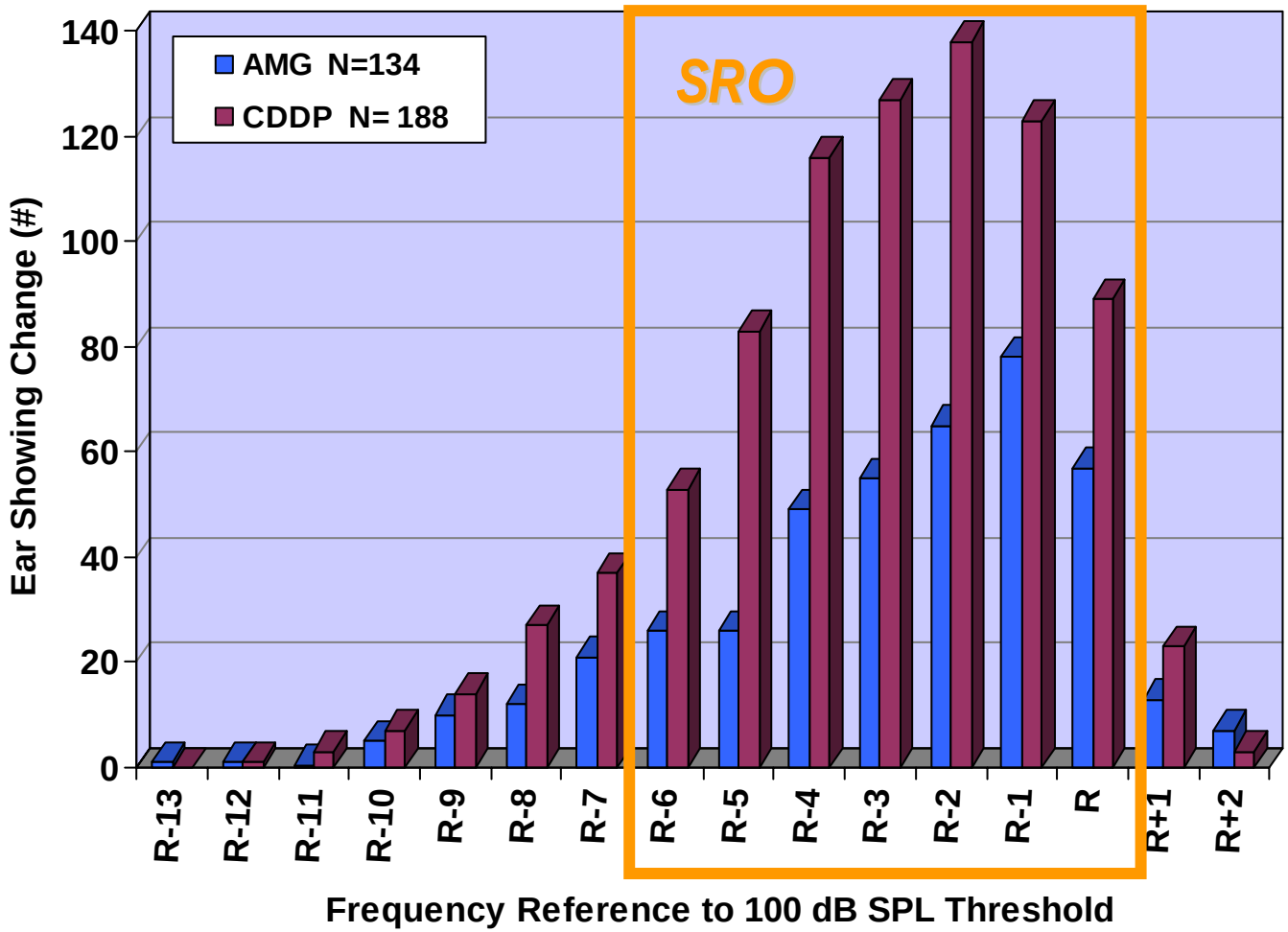
# Highest Audible Frequency



# Highest Audible Frequency



# Initial Ototoxicity Detection

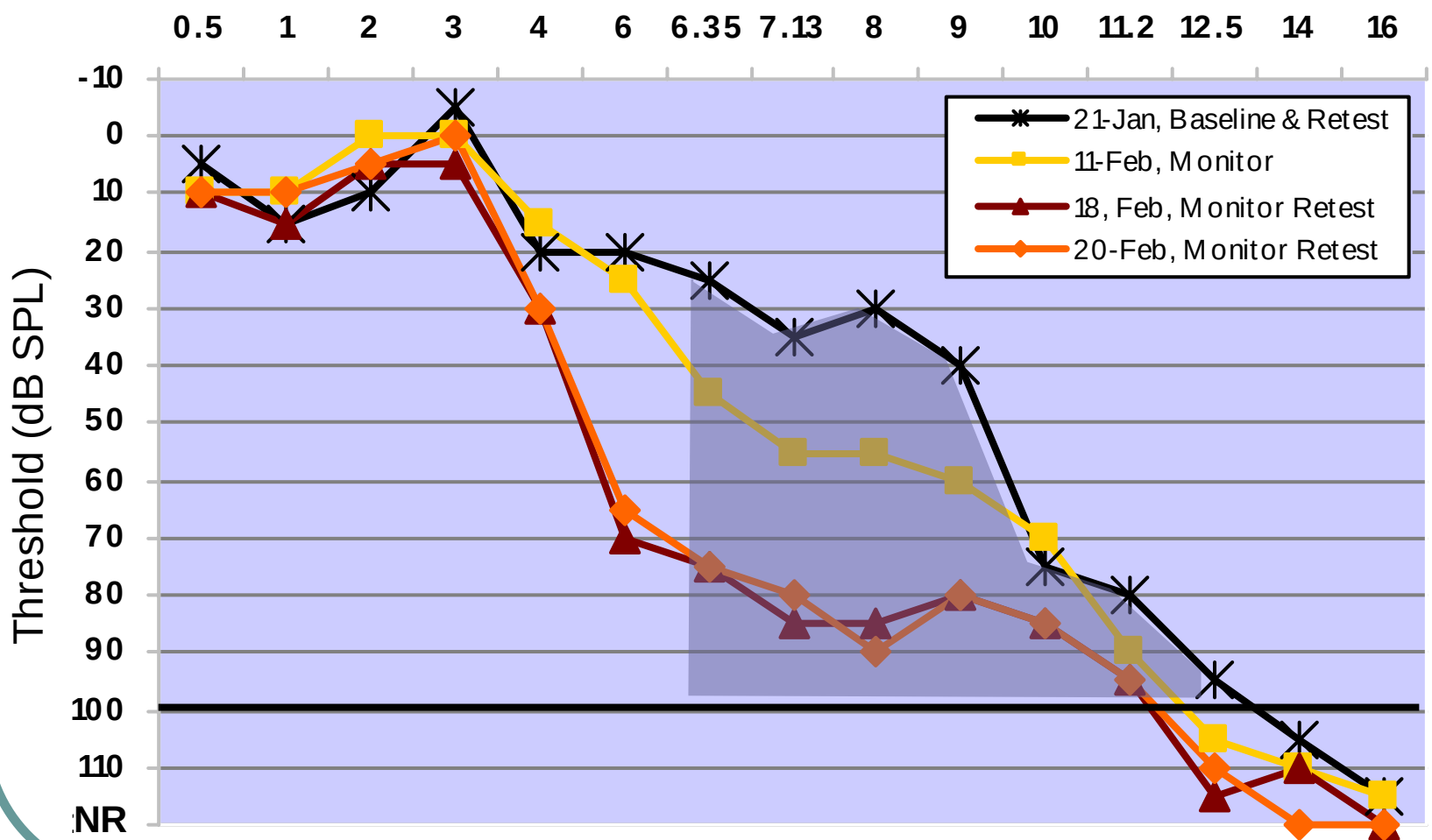


# SRO Principle

- Thresholds > 100 dB SPL remain unchanged
- Most initial changes seen within one octave below the highest audible frequency
- Range for each individual is unique and specific to their hearing configuration

*A sensitive range for ototoxicity (SRO) is the uppermost frequency with a threshold ≤100 dB SPL and 6 lower consecutive frequencies in 1/6$^{th}$ octave steps*

# Case Example using SRO

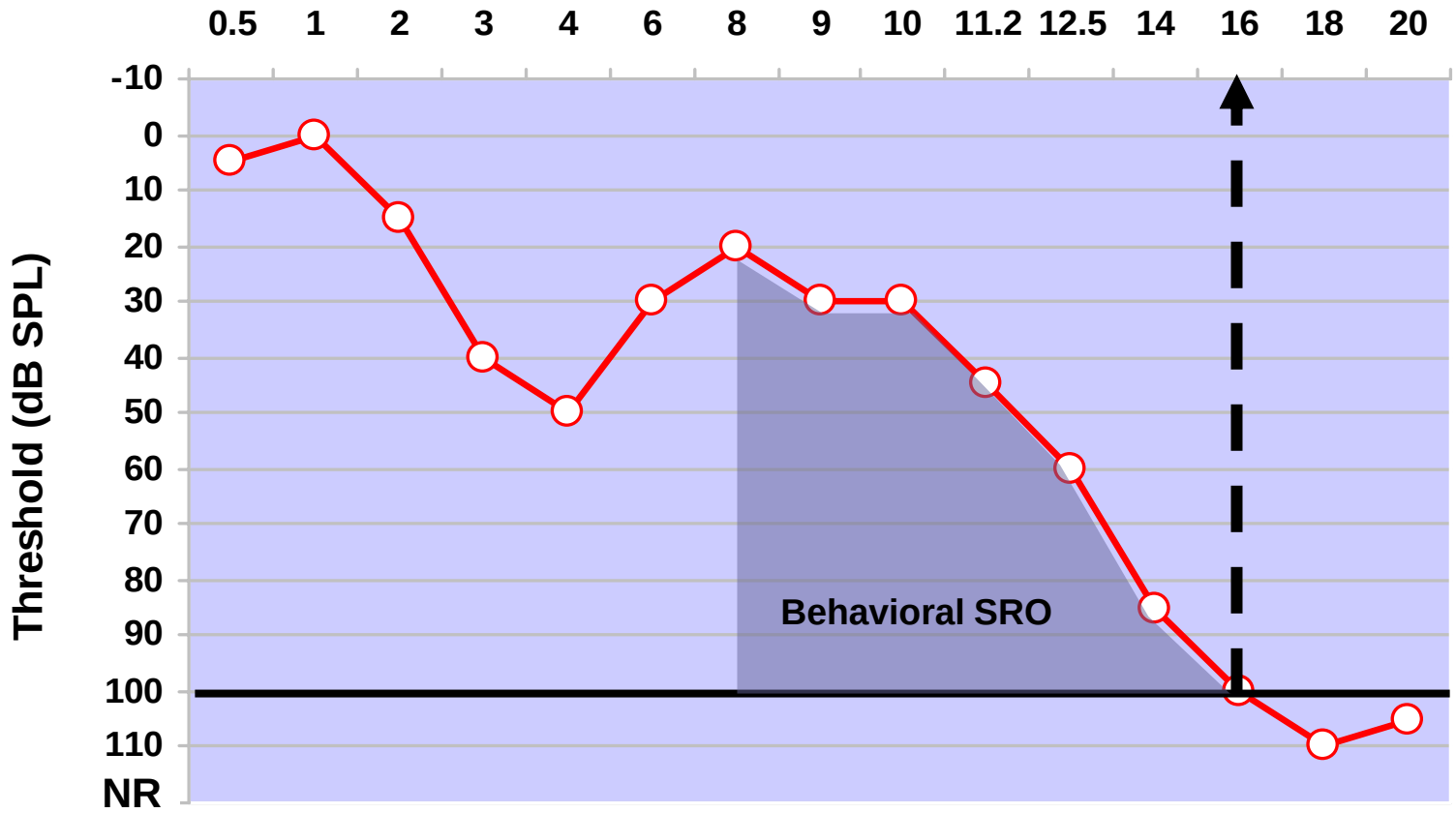


# Sensitivity: SRO 1/6th Octave

| | Total (Ears) | Hit | Miss | Initial Change on SRO |
|---|---|---|---|---|
| **AMG** | 54 | 46 | 8 | 85% |
| **Cisplatin** | 226 | 207 | 19 | 92% |
| **Carboplatin** | 59 | 50 | 9 | 85% |
| **Total** | 339 | 303 | 36 | 89% |

**Fausti SA, Helt WJ, Phillips DS, Gordon JS, Bratt GW, Sugiura KM, Noffsinger D: Early detection of ototoxicity using 1/6th-octave steps. *J Am Acad Audiol* 14(8):444-50, 2003.**

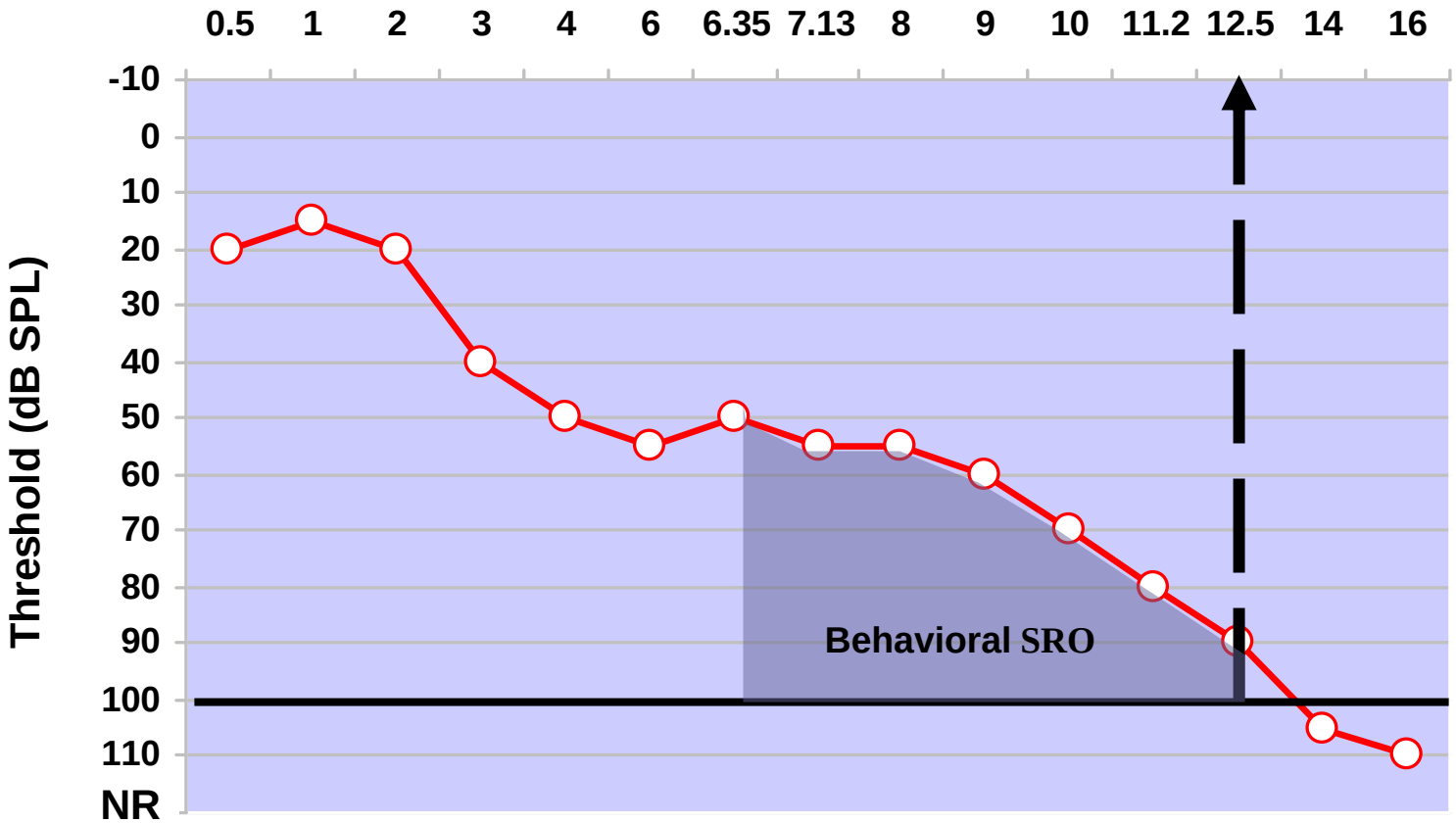
# Example SRO Above 8 kHz




**SRO Test Frequencies:**

**8, 9, 10, 11.2, 12.5, 14, 16 kHz**

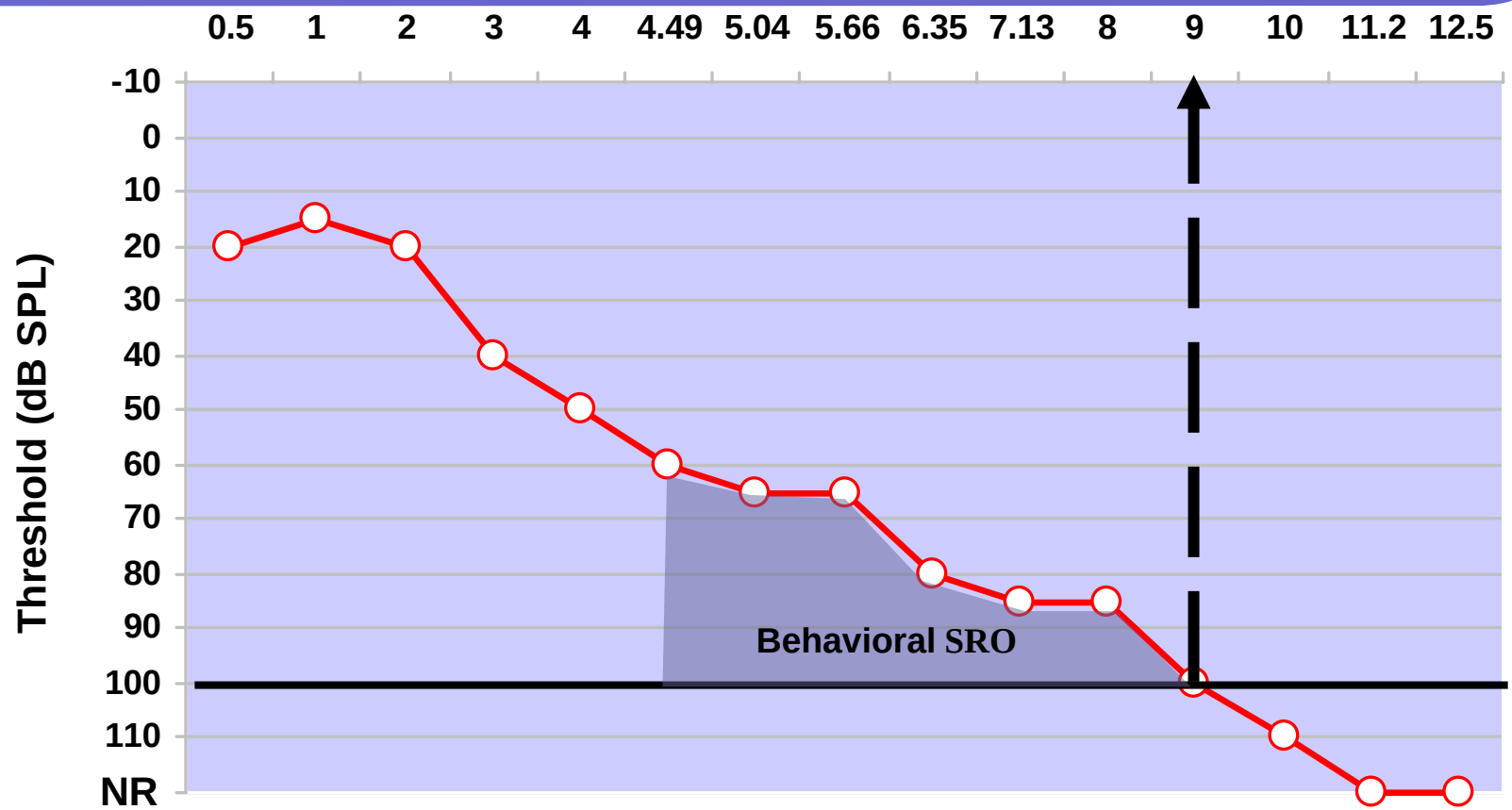
# Example SRO Below 8 kHz




**SRO Test Frequencies:**

**6.35, 7.13, 8, 9, 10, 11.2 12.5 kHz**

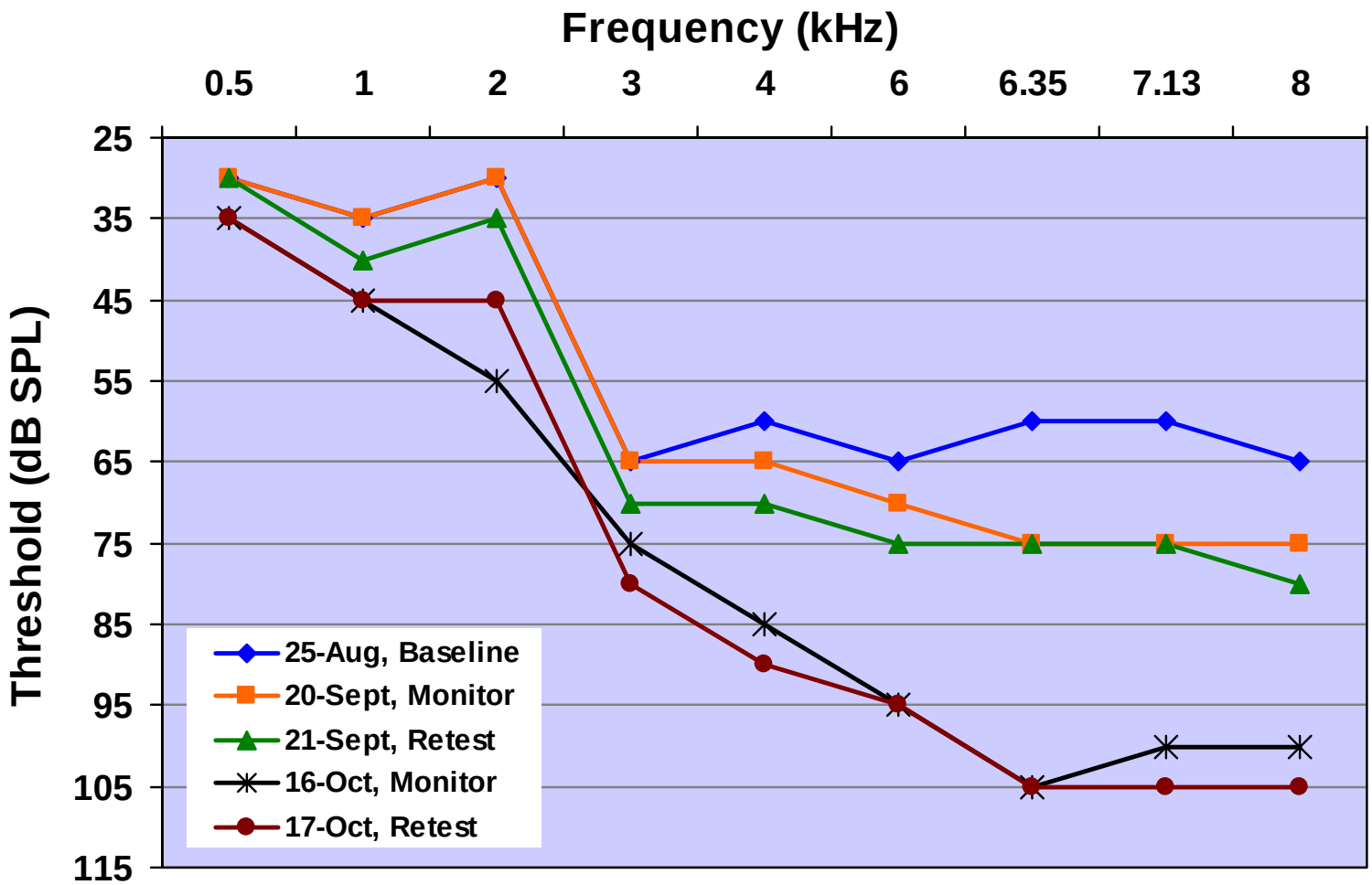
# Example SRO Below 8 kHz




**SRO Test Frequencies:**

**4.49, 5.04, 5.66, 6.35, 7.13, 8, 9 kHz**

# Case Example of Ototoxic Threshold Shifts: SRO < 8 kHz



# SRO Principle

***S*** = ***Sensitive,*** detects ototoxicity 90% of the time

***R*** = ***Range***, 1 octave in 1/6 octave steps (7 frequencies) at the upper limits of hearing

***O*** = ***Ototoxicity***, early detection is key

# Ototoxicity Identification Device

A portable, handheld audiometer-like device that will enable time-efficient, reliable and sensitive early detection of ototoxicity.

# Specificity: Booth vs. Ward

***False Positive rate, using ASHA Criteria***

| | Booth | | Ward | | |
|---|---|---|---|---|---|
| **Earphone Type** | **≥ 20 dB at 1 Frequency** | **≥ 10 dB at 2 Consecutive Frequencies** | **≥ 20 dB at 1 Frequency** | **≥ 10 dB at 2 Consecutive Frequencies** | **Frequency Range** |
| **Koss Pro/4X*** | 0% | 0% | 0% | 7% | 2, 5-16 |
| **ER-4B*** | 0% | 0% | 0% | 0% | 2, 5-16 |
| **Sennheiser HDA 200**** | 0% | 2% | n/a | n/a | 8-16 |

***Gordon JS, Konrad-Martin D, Phillips DS, Helt WJ, Fausti SA: The evaluation of insert earphones for high-frequency bedside ototoxicity monitoring. *JRR&D*, under review.**

****Frank T: High-Frequency (8 to 16 kHz) reference thresholds and intrasubject threshold variability relative to ototoxicity criteria using Sennheiser HAD 200 earphone. *Ear & Hearing* 22 (2): 161-168, 2001.**

# Technical Considerations

- Audiometer
  - High frequencies and 1/6$^{th}$ octave capability
  - Capable of high output with low noise floor
  - Portable
- Earphone Selection
  - High frequency capability
  - High output capability
  - Insert ER-3A and Circumaural TDH-39/49 WILL NOT work for high frequency measurement
- Calibration

# Technical Considerations

- Earphone placement
- Stimulus Tone:
  - Pulsed
  - Increase duration of tone presentation
- Ambient Noise:
  - Single-walled vs. Double-walled sound booth
  - Hospital ward testing
    - Make noise measurements
    - “Do Not Enter - Test in Progress” sign
- Listening check:
  - High frequencies, High Output

*CONSISTENT EARPHONE PLACEMENT IS KEY*

# Conclusions

Evidence-based protocol

Time-efficient protocol

Portability

- High frequencies are reliable
- Sensitive Range for Ototoxicity (SRO) exists
- ~90% initial detection rate using SRO
- Only 7 frequencies in SRO
- OtoID
- Earphones can be used on ward