Evaluation of Near Field Distance Perception in Virtual Environments

175th Meeting of the Acoustical Society of America

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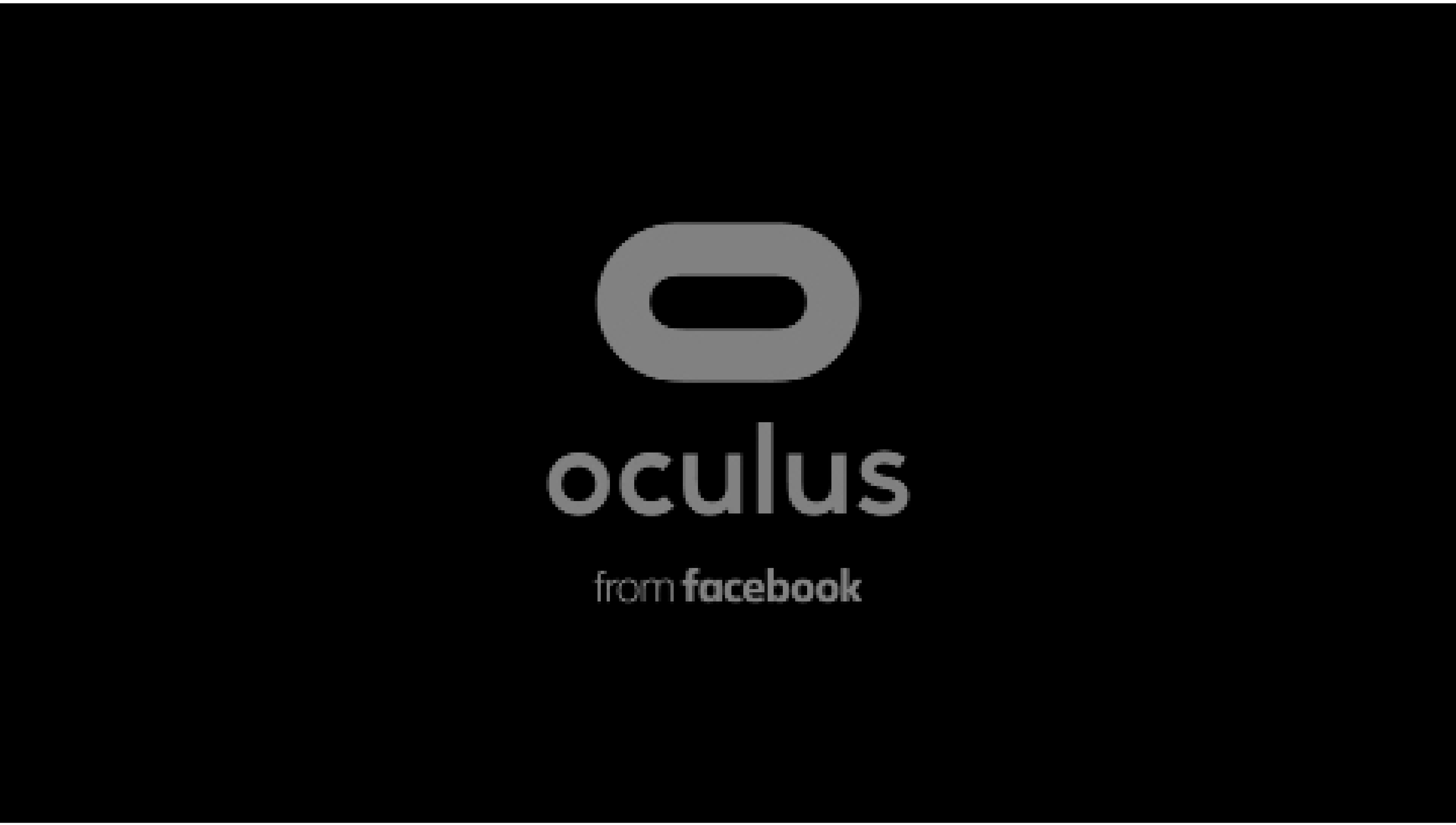
~~Oculus Research~~
Facebook Reality Labs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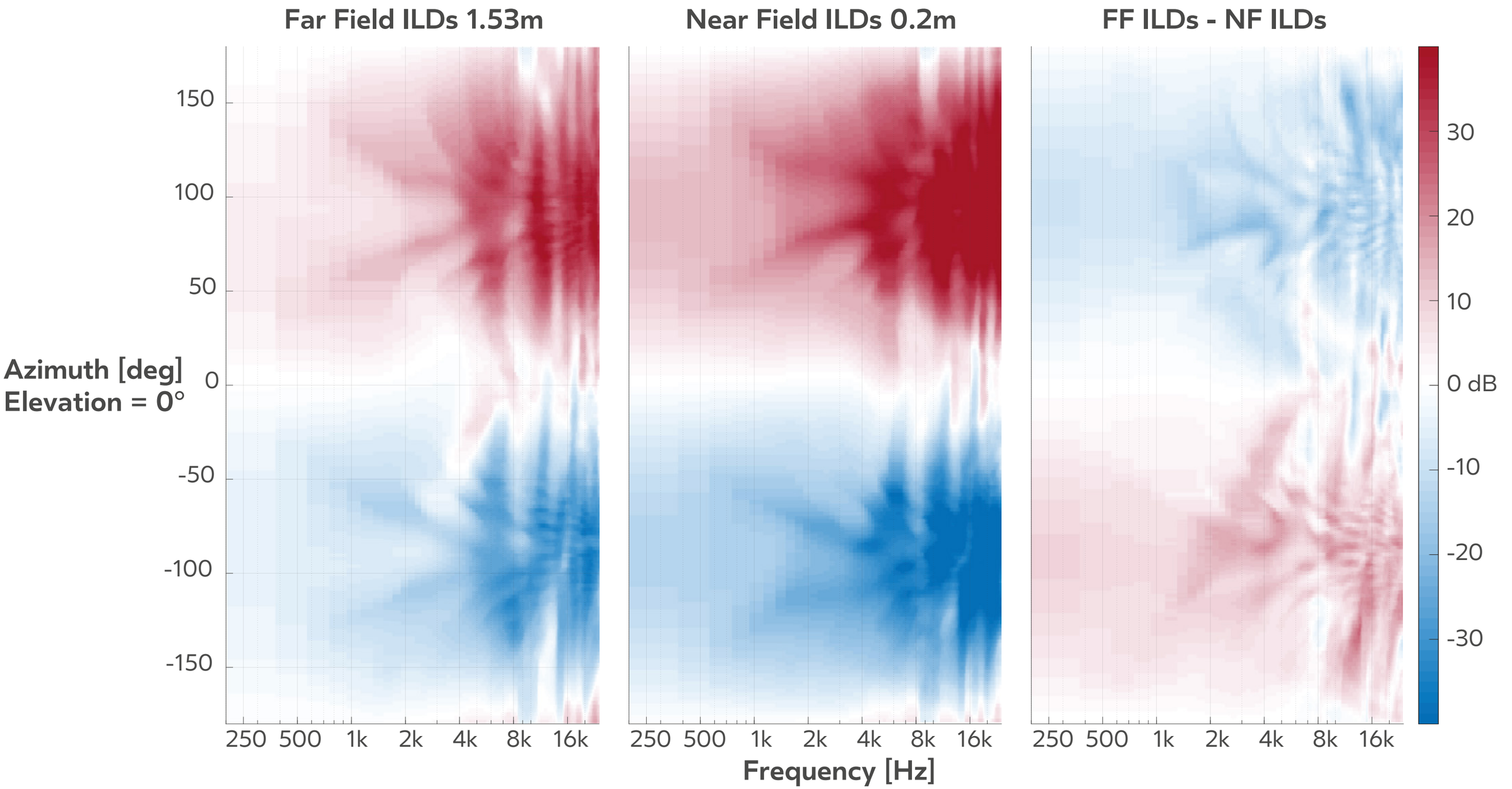
Auditory Distance Cues

- **Loudness** - Requires familiarity w/ source
- **Content** - e.g. Speech effort
- **Early Reflection Timing/Direction of Arrival** - E.g. intimacy in concert halls
- **Direct to Reverberant Ratio** - Very high in the near field

In the Near Field (<1.5m)

- **High ILD with respect to ITD** - Sound dispersion and head shadowing
- **Pinna cues** - Relative angle to each ear changes at near distances
- **Motion Parallax** - Dynamic changes in binaural cues with head movements

Near Field Effects



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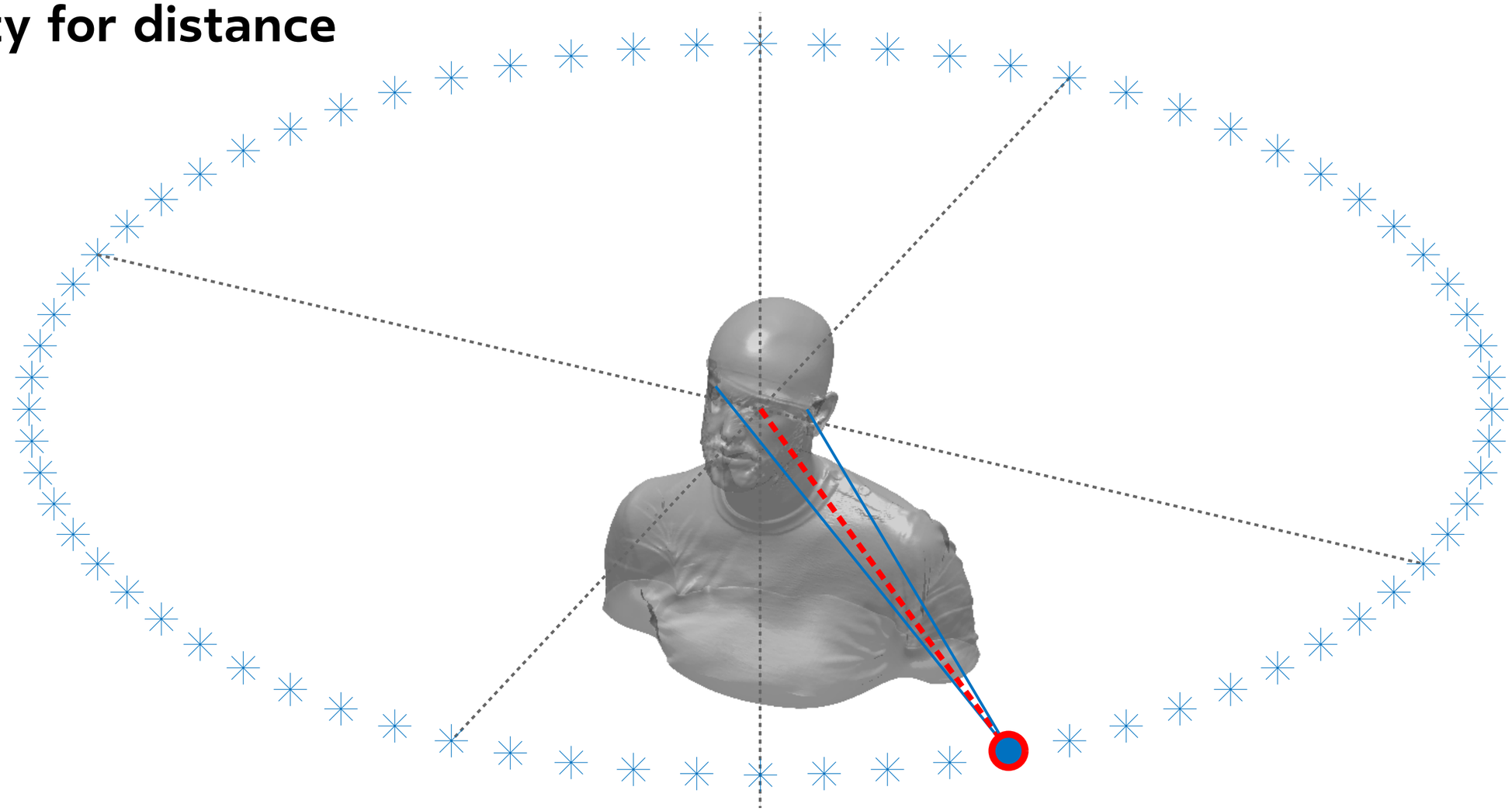
Far Field Binaural Synthesis

- **Measure HRTFs at a distance**
- **Convolve with anechoic audio**
- **Scale intensity for distance**



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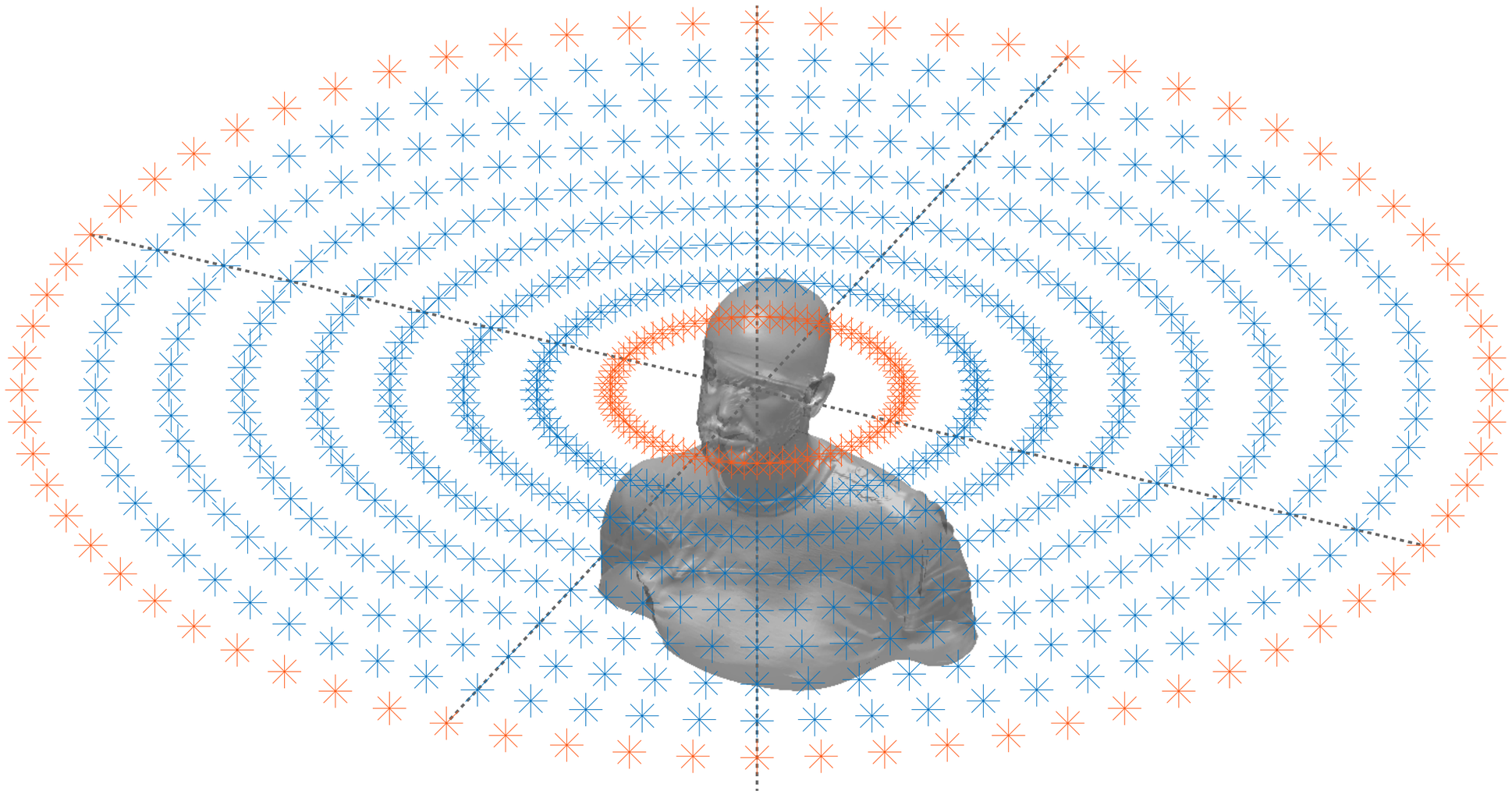
Full Measurement or Simulation

- **Captures all cues**
- **Memory intensive**



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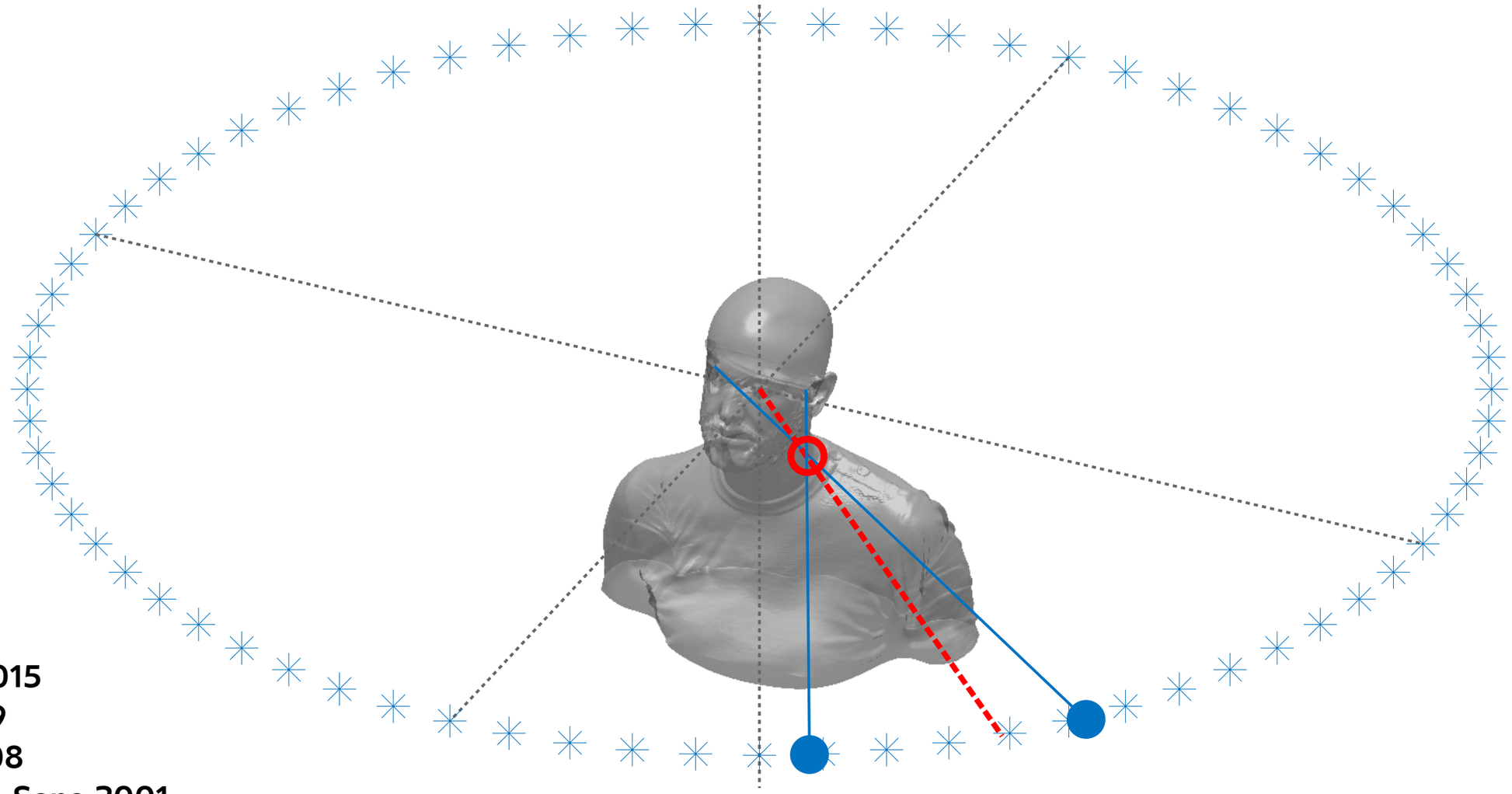
Parallax Model

- **Exaggerated ILDs**
- **Pinna cues correspond to different far field HRTFs**



- **Sunder, Gan, & Tan 2015**
- **Kan, Jin & Shaik 2009**
- **Romblom & Cook 2008**
- **Kim, Suzuki, Takane & Sone 2001**

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Assessment advantages in a virtual environment

- **HRTFs - quick switching between conditions**
- **Reverberation - quick switching between environments**
- **Direct response - free space pointer placement**
- **Elimination of visual distraction**
- **Feedback - Visual, Proprioceptive, Haptic**

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How can we measure nearfield perception? Challenges

- **Response Methods**

Direct Report - **Zahorik 2002**
Anderson & Zahorik 2014

2D Mapping - **Iyer, Thompson & Simpson 2016**

Pointing in reference to a model - **Brungart, Rabinowitz, & Durlach 1998**

Direct pointing - **Brungart, Rabinowitz, & Durlach 1998**
Parseihian, Jouffrais & Katz 2014
Kan, Jin & Shaik 2009
Etchemendy et al 2017 - Floating LEDs

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How can we measure nearfield perception? Challenges:

- **Visual interactions**

  Zahorik 2001
  Bowen, Ramachandran, Muday & Schirillo 2011
  Anderson & Zahorik 2014

- **Multimodal feedback and learning**

  Bălan, Nagy & Botezatu 2015
  Mendonça, Campos, Dias & Santos 2013
  Honda et al 2013
  Parseihan & Katz 2012
  Majdak, Goupell & Laback 2010
  Zahorik, Bangayan, Sundareswaran, Wang & Tam 2006

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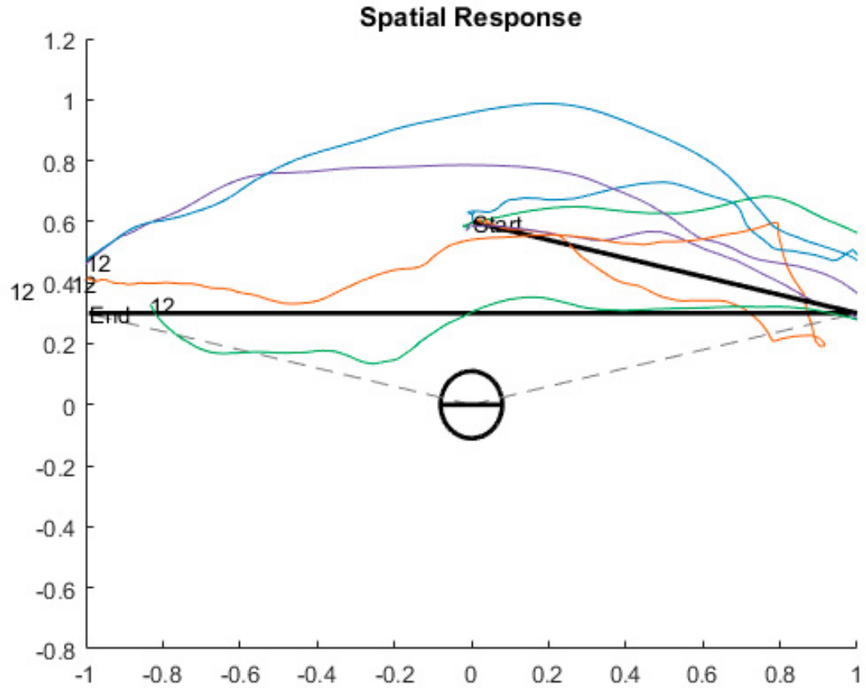
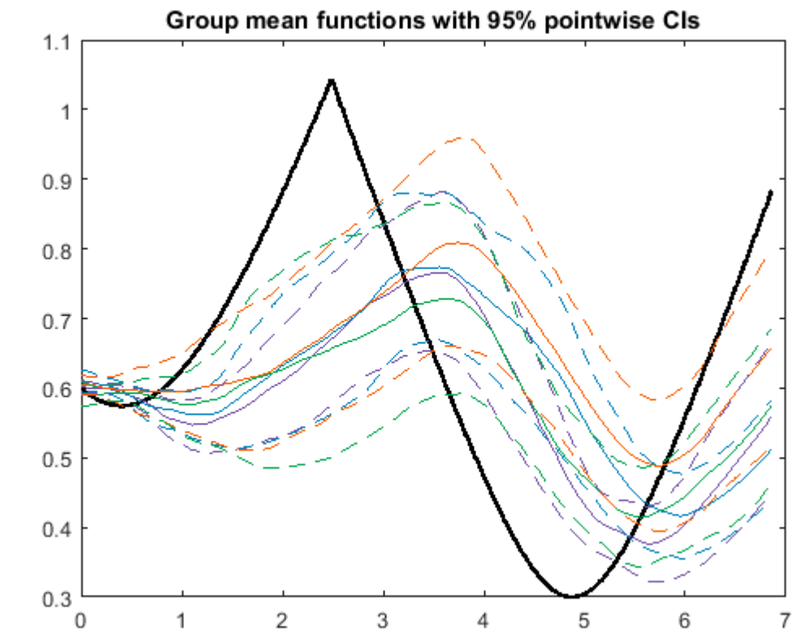
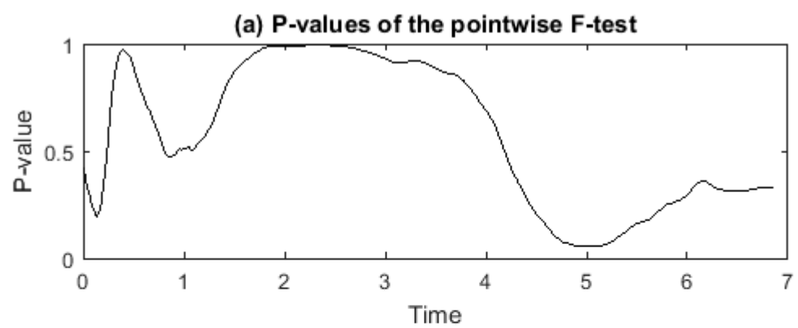
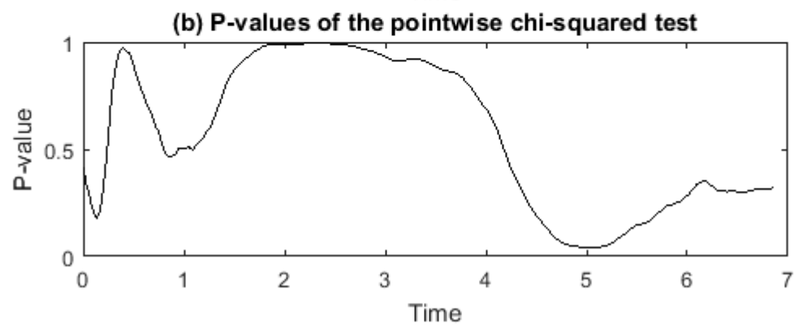
Pilot Results









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Thank you for listening!

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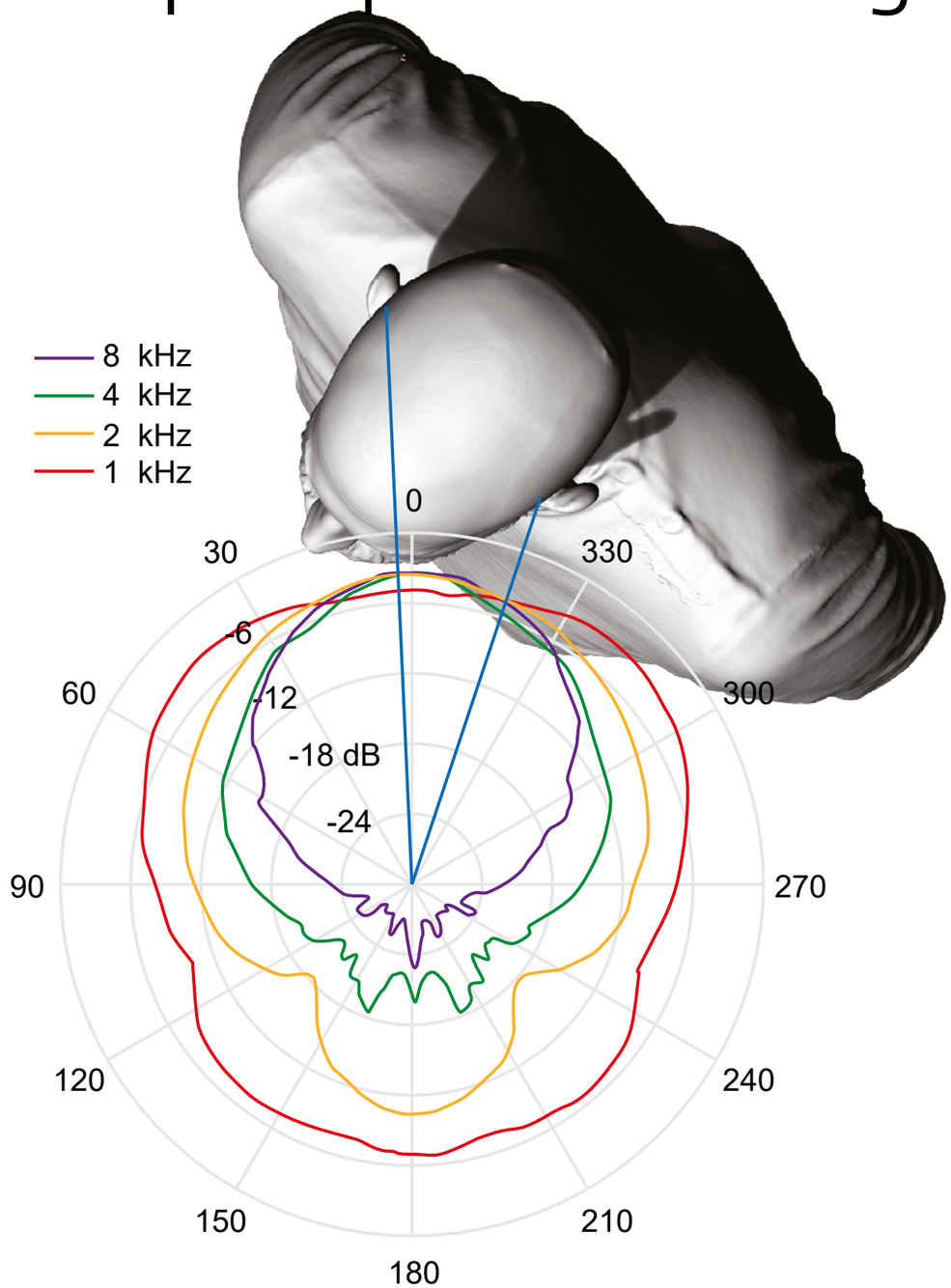
Thank you for listening (closely)!

How can we measure nearfield perception? Challenges:

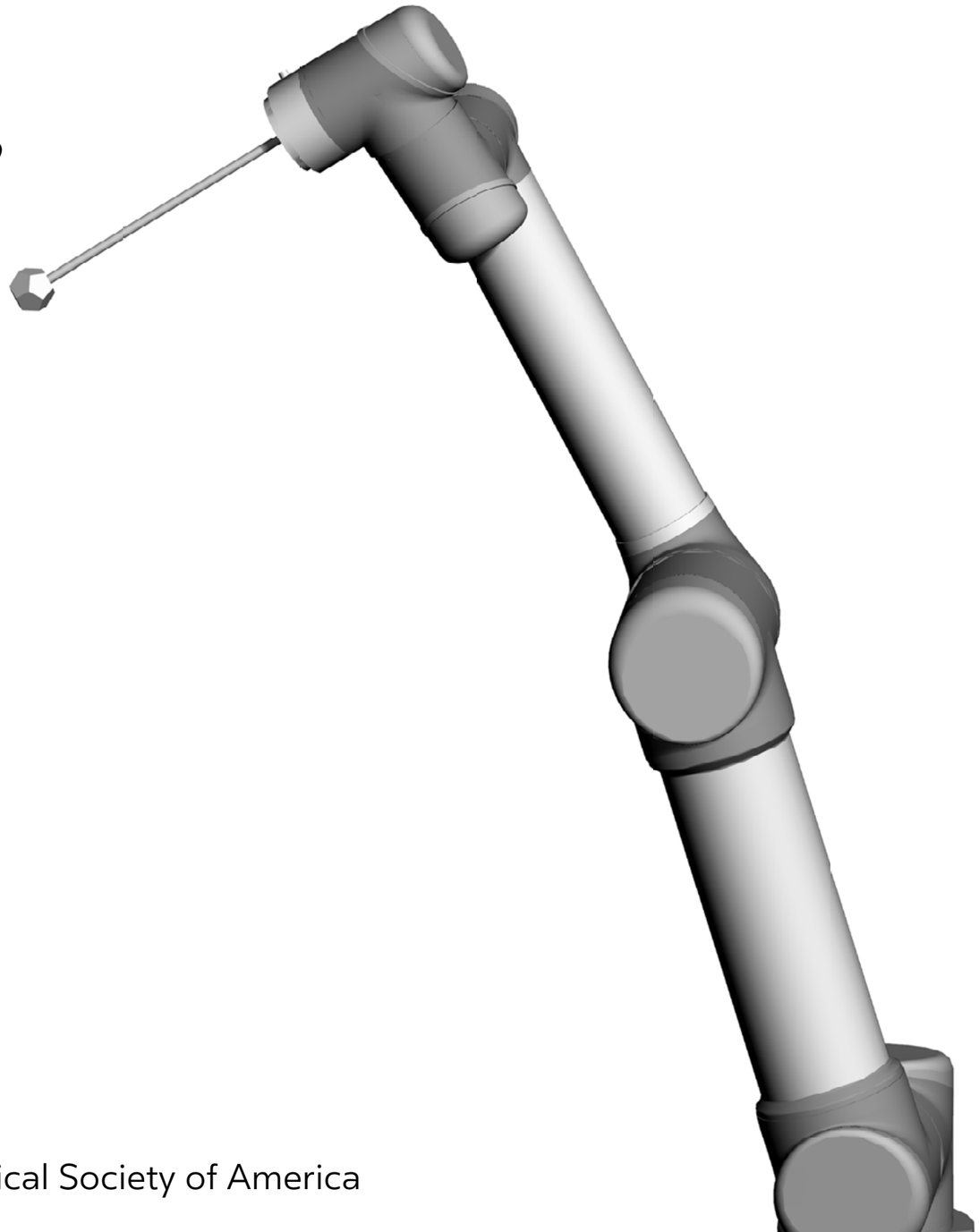
- **Sound Source**
  3-5 cm max source size
  Omnidirectional



- **Guang-Zheng et al 2008 - Scattering**
- **Guang-Zheng et al 2010 - Omni source**
- **Calamia & Hixson, 1997**

How can we measure nearfield perception? Challenges

- **3D placement**
  Manual placement - **Brungart, et. al. 1999**
  Fixed Placement - Table top
  Parseihian, Jouffrais & Katz 2014
  Mace et al 2012



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Evaluation Conditions

- **Far Field - Intensity scaling**
- **Full Depth Simulation / Measurement**
- **Near Field Compensation**
- **Individualized vs Generic**