GETTOP 共达

Technical Whitepaper on Directional Boom Microphones

Professional Acoustic Solutions

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Market Background and User Needs

Currently, TWS wireless products dominate the headphone market for consumers. However, there is a separate and independent rigid market segment for wired headphones with extendable boom microphone (Boom Mic) headsets, which is not affected by the widespread adoption of wireless technology. The category structure is highly concentrated in three scenarios: office communication accounts , e-sports gaming accounts, and online teaching /light content creation accounts for. Core growth sources include government and enterprise bulk purchases, e-sports peripherals, and education centralized procurement.

With the widespread adoption of remote working, e-sports competitions and online audio-visual scenarios, headsets with microphone arms and in-ear headphones have become the core audio equipment for government and enterprise communications, e-sports interactions, and online teaching. The market penetration rate has continued to rise, and domestic shipments are expected to achieve steady growth in 2025. However, as the scenarios become more diversified, industry product pain points persistently emerge. Issues such as ambient noise in open office environments, background noise during game sessions, and interference from environmental reverberation that cause unclear call reception and low voice-to-noise ratio in human speech have become the core bottlenecks restricting the upgrade of headsets' audio experience and their professional popularization.

This white paper focuses on the core audio-receiving component of head-mounted headphones - the directional microphone of the boom. It delves into the technical logic of the specialized audio-recording solution. The core objective of this solution is to achieve directional audio pickup, relying on acoustic structure optimization and iterative sound field simulation, to precisely focus on the near-field human voice near the mouth, significantly suppressing lateral and rearward environmental noise, effectively improving the purity and signal-to-noise ratio of the human voice, while balancing high-definition call experience and efficient noise suppression capability, and being suitable for complex audio-recording environments in all scenarios.

This article will deeply dissect the core acoustic principle of this technology - the cardioid directivity (Cardioid Directivity) sound pressure gradient pickup mechanism. It will conduct theoretical analysis and provide application recommendations on how to select directional microphones in microphone pole applications.

02

Directional Design of Boom Microphone

Analyze principle of directional microphones, establish a physicalmodel of the microphone capsule, and optimize performanceparameters and directivity through COMSOL simulation analysis.

Single-microphone heart-shaped physical pointing principle

Core mechanism: Pressure Gradient Principle

The diaphragm cavity of the microphone consists of the front sound hole (near the mouth end) and the rear sound hole with damping. The amplitude of the diaphragm's vibration is determined by the difference in sound pressure between the two sides, which forms the physical basis for directionality.

$\Delta P = P\_front - P\_back$

ΔP represents the difference in sound pressure between the two sides of the diaphragm; P_front is the sound pressure at the front sound hole, and P_back is the sound pressure at the rear sound hole after damping attenuation. The greater the pressure difference, the more intense the vibration of the diaphragm.

Direct frontal sound wave incidence

The sound waves directly reach the front sound hole. The rear sound hole has a very small P_back due to its long path and damping attenuation, while ΔP is at its maximum. The diaphragm vibrates fully, and the signal is efficiently picked up.

Backward/Sidewave Impingement

The sound waves simultaneously reach the front and back sound holes. $P\_front \approx P\_back$, and ΔP approaches 0. The diaphragm hardly vibrates, effectively suppressing the noise from the rear.

Technical advantages

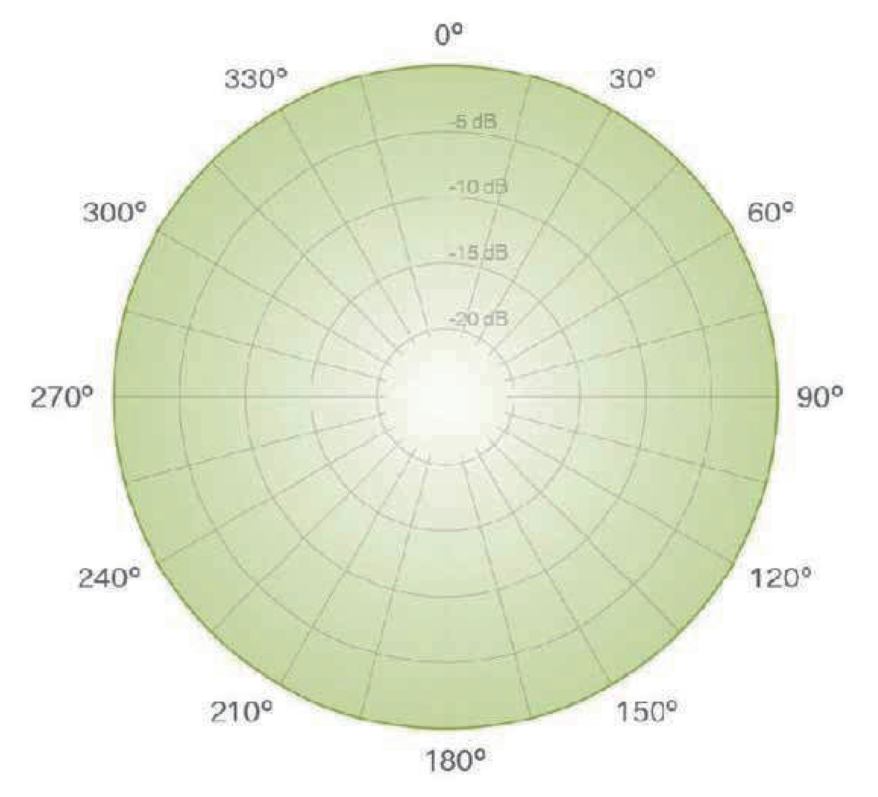
The structure is extremely simple, without the need for complex DSP algorithms. The hardware cost is low, the power consumption is small, and it is easy to be integrated into various portable devices.

Application limitations

The angle is relatively wide (±60°), and its ability to suppress non-steady-state noises (such as keyboard strikes and desk reverberation sounds) is limited.

Boom Microphone polarity selection technique

Directional omnidirectional microphone:



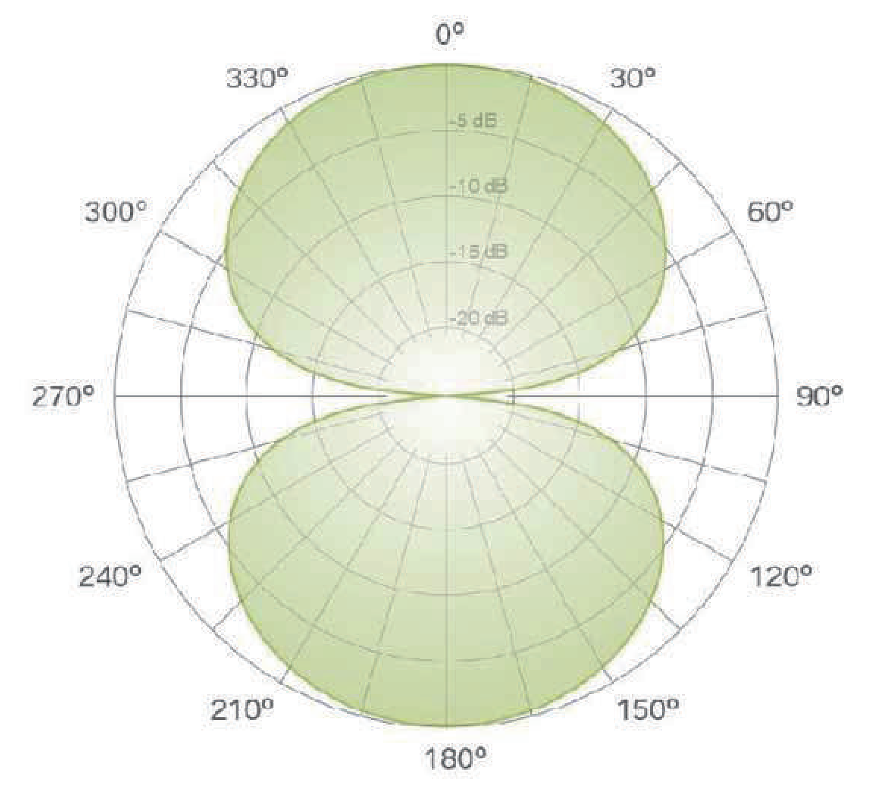
The pressure microphone can uniformly pick up sounds within a 360-degree range. It exhibits the same sensitivity in all directions and there is no difference of sensitivity between "front, back, left and right".

"Listen to it anywhere, record the world, rather than filtering out the sounds. "

Advantages: The sound is natural and true, with a flat low-frequency response and no "near-speech effect".

Disadvantages: It cannot isolate noise and is easily affected by the environment.

Bidirectional/Figure-of-eight Microphone：



The differential pressure microphone only records the sounds directly in front and behind the diaphragm, and does not pick up sounds from the sides.This type of microphone can produce highly realistic sound reproduction and capture the natural atmosphere of the entire recording space.

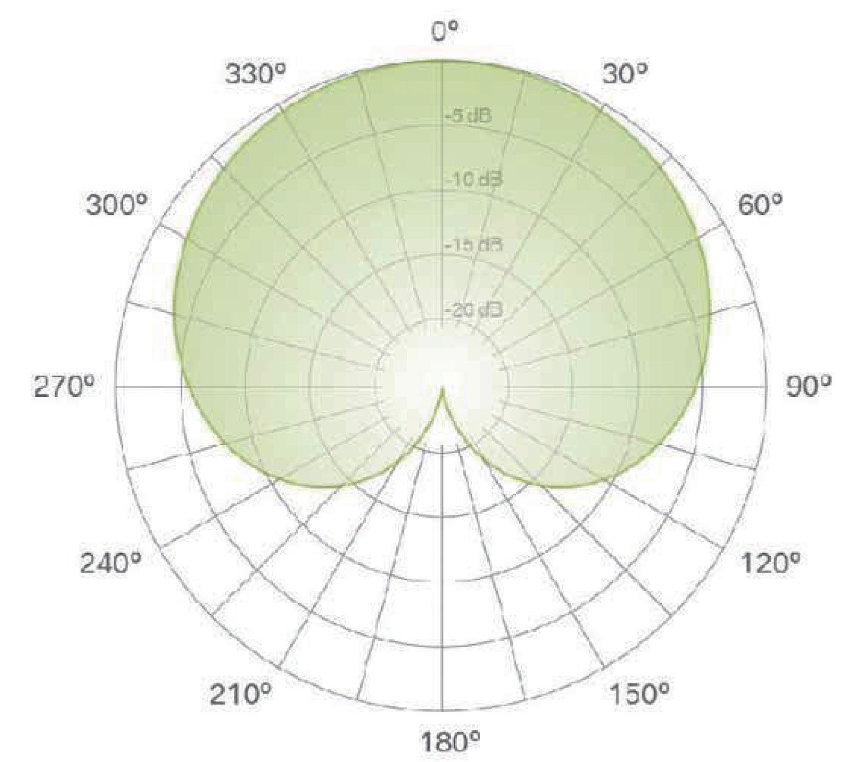
"Both front and back are needed, but not the sides. I want all the sounds on a straight line. "

Advantages: Precise spatial control, suitable for stereo technology.

Disadvantages: It is prone to picking up background noise from the rear, and the usage threshold is relatively high.

Boom Microphone polarity selection technique

Cardioid Microphone :



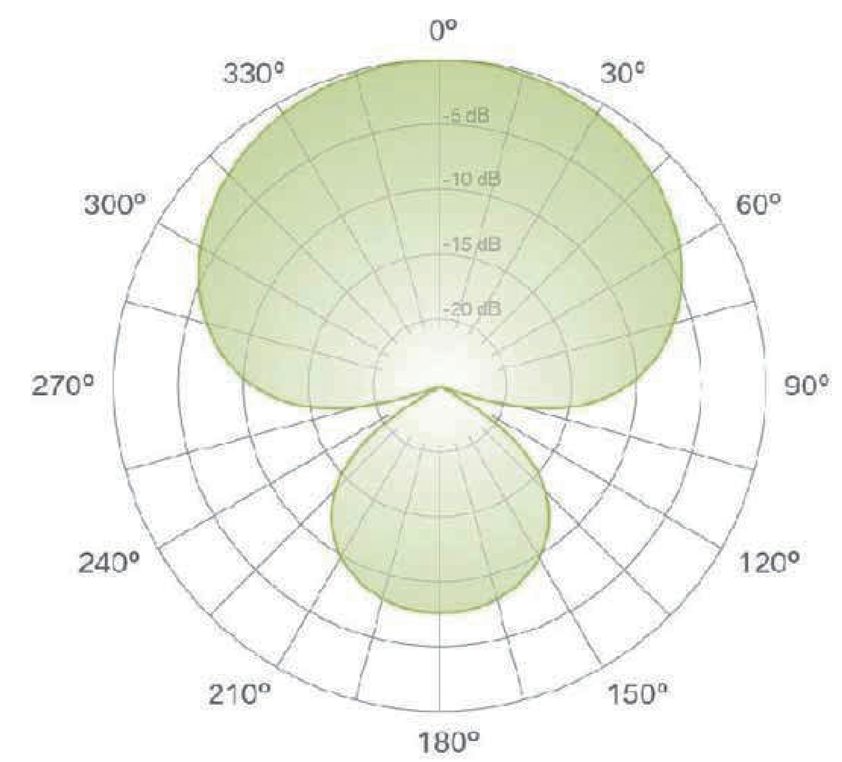
The cardioid microphone, which is composed of a pressure microphone and a differential pressure microphone, is by far the most commonly used directional pattern. It gets its name because of its heart-shaped shape. It is most sensitive in the front, attenuates on the sides, and strongly suppresses on the back.

"Listen to what you want and don't listen to what you don't want. 90% of people, this will be enough for them. “

Advantages: Strong noise reduction capability, reduces environmental interference, widely used.

Disadvantages: There is a "near-talk effect" (low-frequency enhancement), sensitive to positioning.

Supercardioid Microphone :



The super heart-shaped microphone has a narrower forward pickup angle than the heart-shaped one, stronger side suppression, and a small pickup "tail lobe" at the back. It has a more concentrated directionalality but a more complex control.

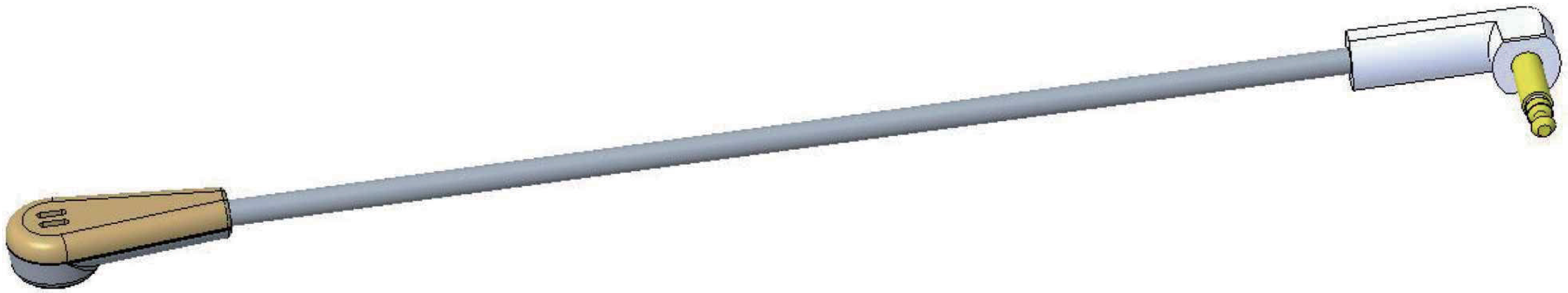
"Smaller than the heart-shaped one, but still 'usable and with high tolerance'"

Advantages: Stronger sound source isolation ability, more effective suppression of side noise, higher direct sound ratio, and clearer sound.

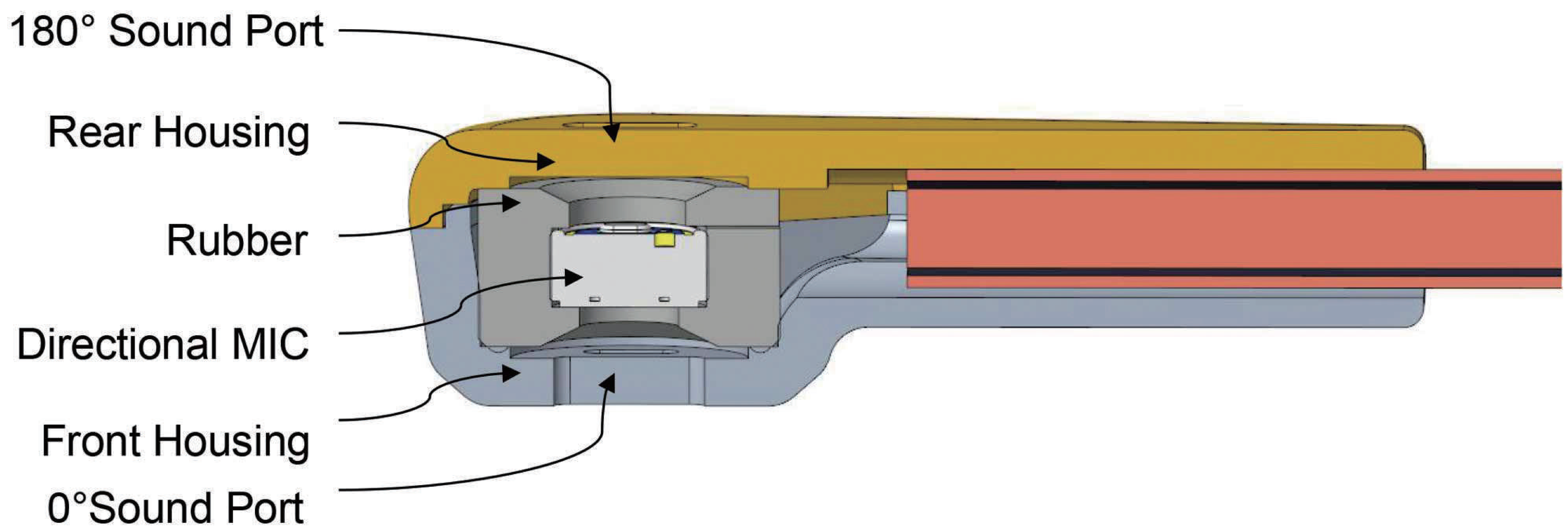
Disadvantages: The rear pickup tail lobe may introduce unwanted sounds; it requires stricter microphone directionality, and the effect will deteriorate if the direction is slightly off; improper use may lead to an unnatural sense of space.

Boom Microphone Structural Design Case

Product Drawing



Partial Structural Cross-section



Advantages:

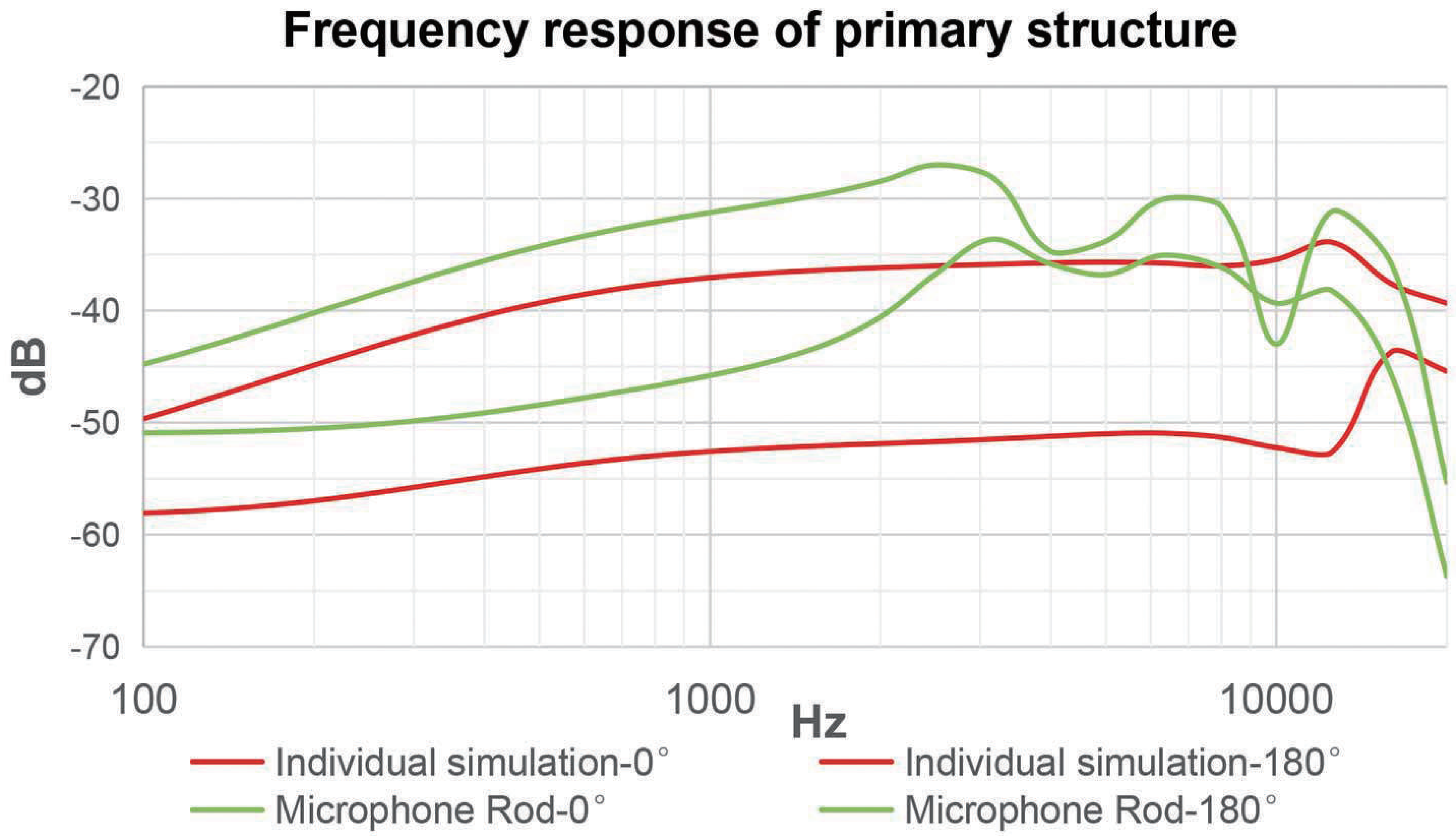
The boom microphone features a simple structural design. Its external structure has minimal impact on polar pattern and frequency bandwidth, enabling ultra-wide frequency response performance for the product.

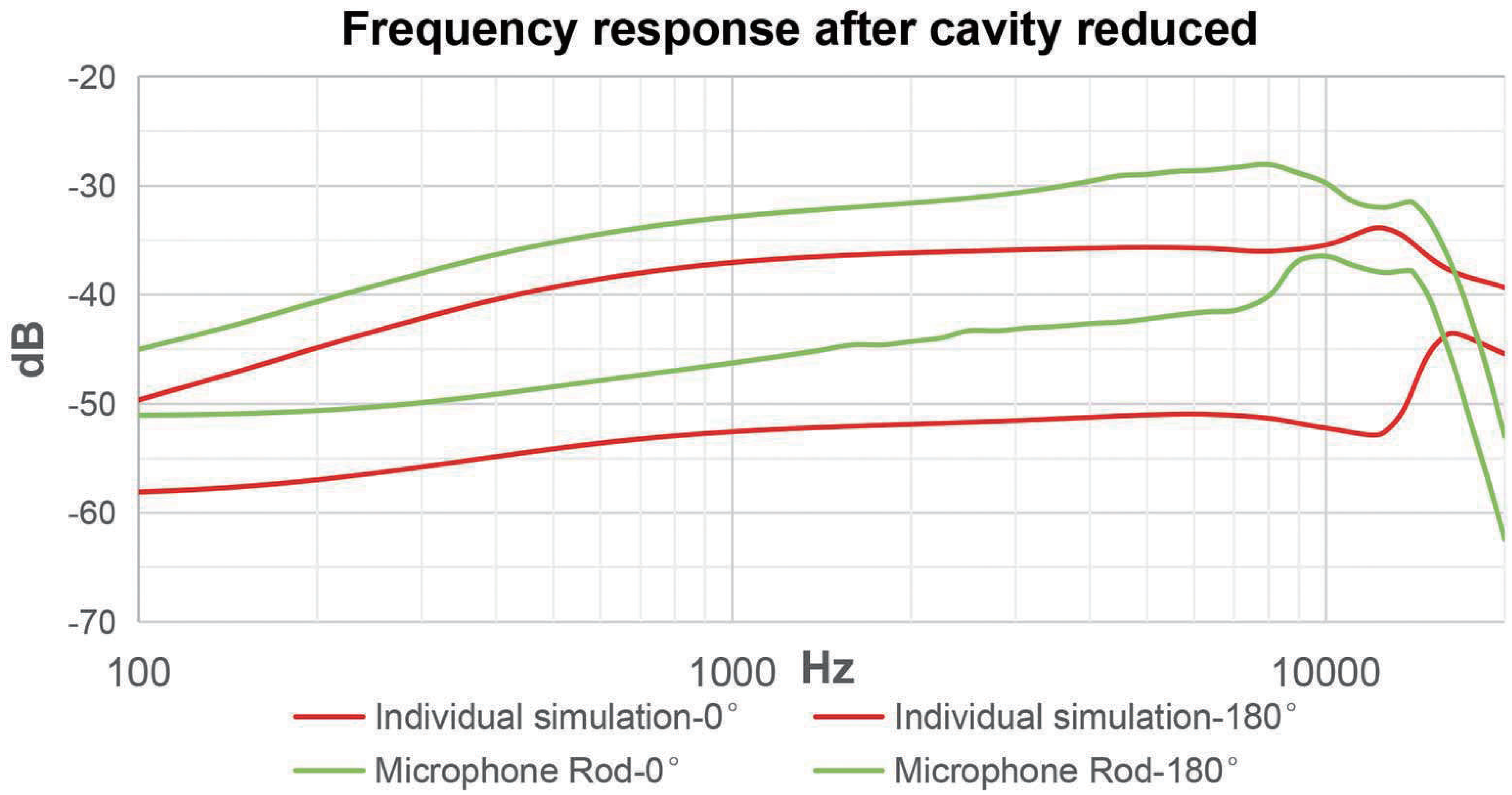
03

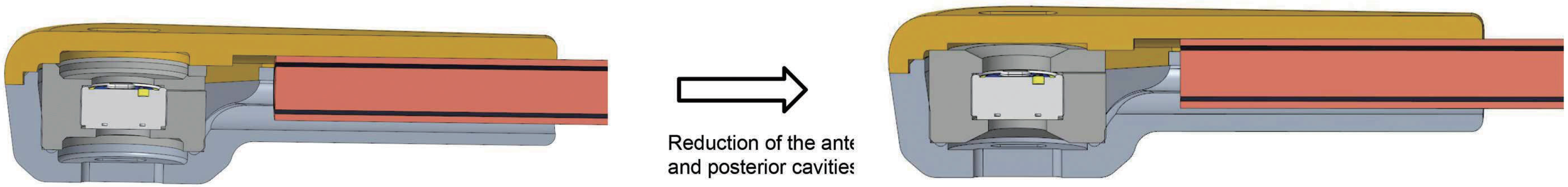
Performance Simulation and Data Analysis

After conducting theoretical analysis, we need to present the data. This chapter will present the performance differences of different technical solutions in actual scenarios through simulations and analyses of key indicators. The presentation will be intuitive and quantitative.

The impact of structural design on bandwidth







By adjusting the size of the cavity, the bandwidth can be improved, achieving a wider frequency response.

04

Key Materials and SimulationTechnology

The realization of high-performance microphones is inseparable from breakthroughs in core materials and the application of advanced simulation technologies. This chapter will explore the key material characteristics that affect the performance of microphones, mainly focusing on the influence of acoustic impedance materials on directionality.

Key material damping effect and simulation technology

- **Key materials**

In the design of directional microphone rods, the damping material directly determines the quality of the acoustic directional characteristics. Its performance is crucial as it significantly affects the degree of sound cancellation at different angles of the microphone rods.

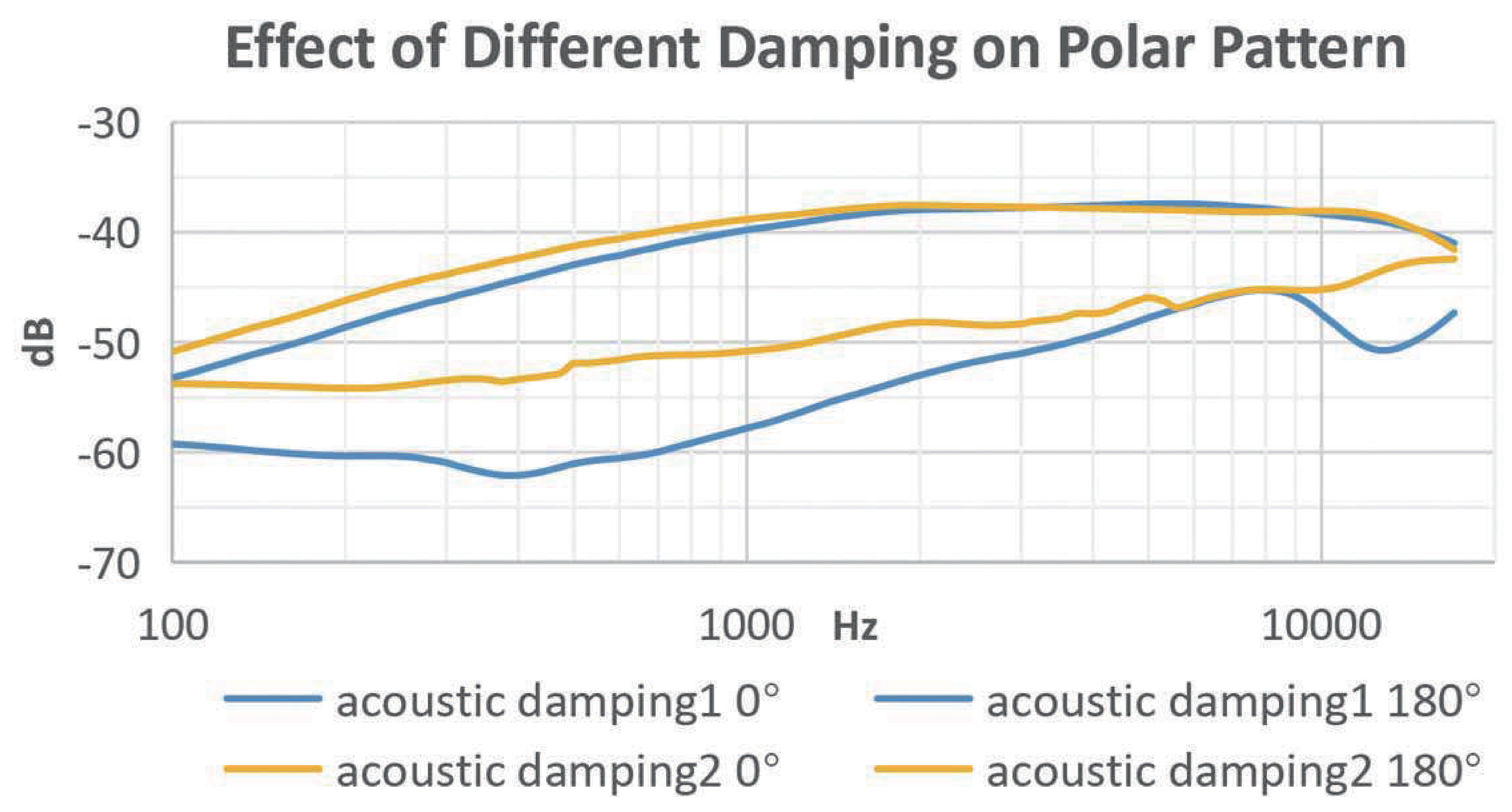
- **Core characteristics of damping materials**

The key acoustic characteristic indicators of an ideal damping material:

- Controllable and precise acoustic resistance: Through acoustic resistance control, ensure the consistency of product directionality;
- Uniform mesh height: Uniform acoustic influence across the entire frequency range, with little impact on the frequency bandwidth of the microphone rod;
- Pure resistive acoustic impedance, with extremely small capacitive/reactive components: Controllable impact on the resonances of the acoustic cavity, and stronger consistency and stability for the microphone rod;

- **Simulation technology**

- Input the structural design model into the simulation software for modeling. By adjusting the parameters of the damping material, the preset design indicators of the rod are achieved.



Summary

GETTOP used Comsol to simulate the usage scenarios of the microphone rod, which helped reduce the number of prototype machines required for DOE verification, significantly shortening the R&D cycle and saving costs, and also shortening the project duration.

GETTOP has mastered the complete Comsol simulation model library, as well as the ability to adjust the polarity of different microphone rods by using these complex structures and materials.

GETTOP has rich production experience and design simulation capabilities in the field of microphone pole directional applications. It can provide end users with the most optimal design optimization solutions and products, creating a win-win value loop for both users and enterprises.