Introduction to the Soundskrit Beetle Kit

Figure 1: Soundskrit Beetle Kit

The Beetle kit is an easy-to-use evaluation kit designed to demonstrate Soundskrit's Direction-of-Arrival (DOA) algorithm. It includes the Beetle PCB, which has three orthogonal Soundskrit dipole microphones and an omnidirectional microphone, connected to Soundskrit's custom audio interface, and a Windows-based GUI.

The microphone signals are used to determine the direction of an incoming sound and automatically steer a directional beam accordingly. The beamformer can be manually steered along the horizontal plane and the vertical plane. Additionally, an immersive stereo mode outputs two directional beams in a stereo signal.

What's In the Box	
Beetle with audio interface, mounted in a microphone shell	Beetle (pre-assembled, ready for use)
USB-A to USB-C Cable	Cable to connect the Beetle to your computer

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Table of Contents

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System Overview

The image below shows an overview of the Beetle demo kit. The Beetle is connected to Soundskrit's custom audio interface, which gets connected via USB to a Windows PC. On the PC, a Soundskrit GUI processes the microphone signals to detect the direction of arrival of a user speaking and beamforms to this direction. The output audio signals from the GUI can be recorded with a recording software like Audacity.

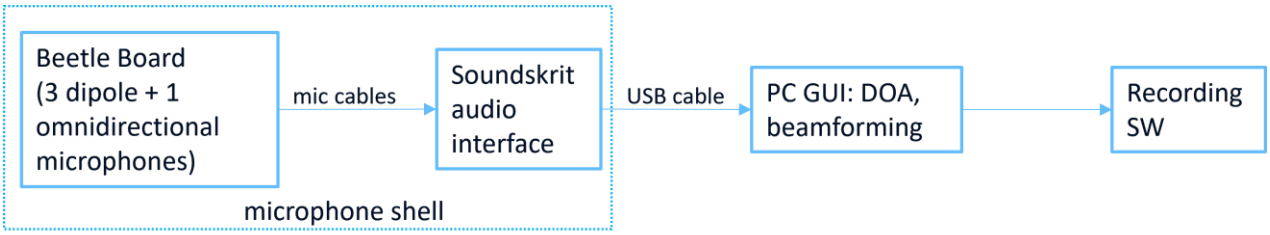

Figure 2: System overview of the demo kit.

Hardware

The Soundskrit Beetle uses one omnidirectional microphone (W) and three Soundskrit dipole microphones which are oriented along three orthogonal axes (X, Y, and Z) to cover the 3D space. The PCB is integrated into a microphone shell for easy handling and protection.

The three images below show the placement of the Beetle in the microphone shell, the four microphones, the orientation of the dipole microphones, and the front (0°) side of the microphone.

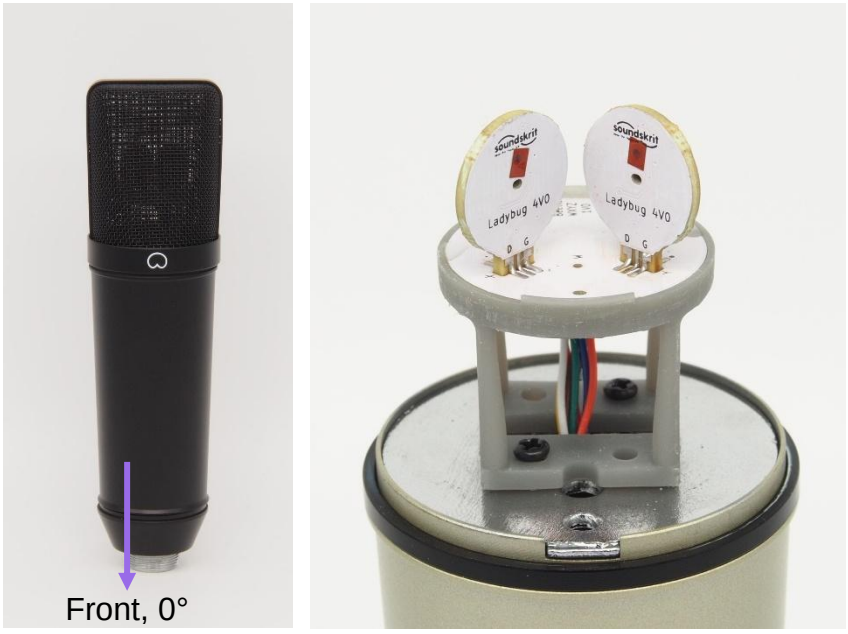

Figure 3: Microphone shell with Soundskrit Beetle integrated (left). Beetle PCB without microphone screen (right).

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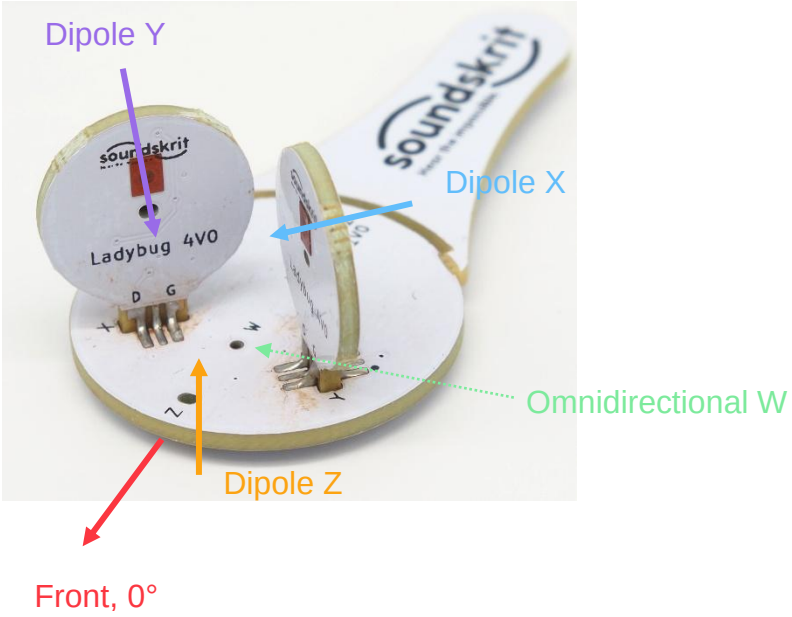

Figure 4: Beetle PCB microphone placement and board front side. The PCB holding tab on the right is removed if the beetle is mounted in a microphone shell.

The Beetle connects via a USB-C cable on the bottom of the microphone shell to a PC.

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Quick Start Guide

Installation

Connect the Beetle to your PC using the included USB-C to USB-A cable.

Download and launch the installer file (Installer_Beetle_Soundskrit.msi) from soundskrit.ca/beetle, then follow the installation steps. A prompt may appear requiring approval for an unknown publisher.

To start the software, search from the Windows start menu for ‘Soundskrit GUI Beetle’ or use the desktop shortcut generated by the installer.

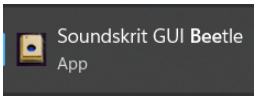

Figure 5: Soundskrit DOA GUI in Windows 11 start menu after installing the software.

Initial Configuration

In the interface, select *Options* and then *Audio/MIDI Settings…* in the top left:

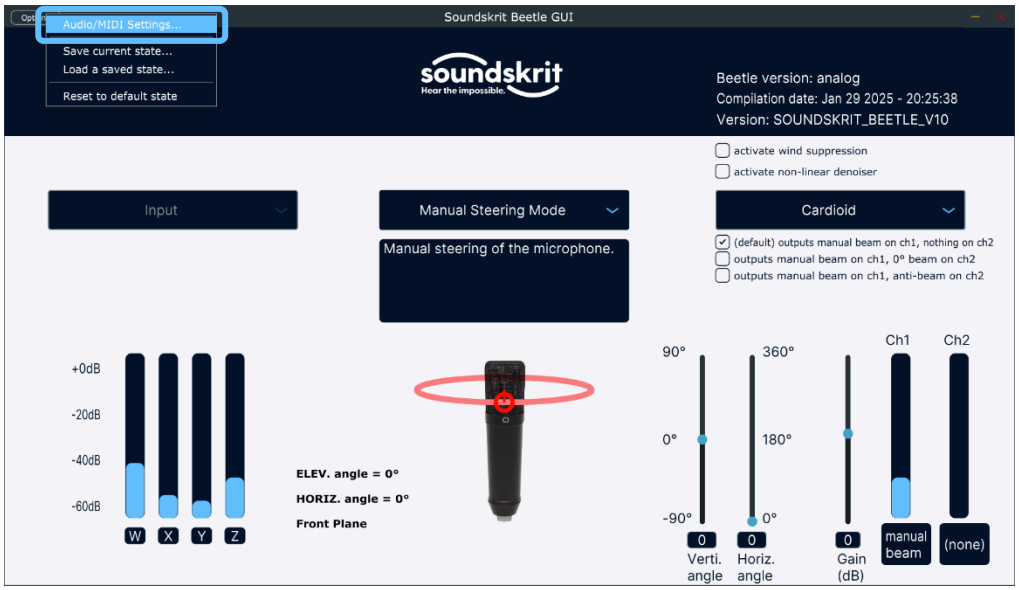

Figure 6: Options Menu in Soundskrit DOA GUI

In the options menu, ensure that the following options are selected:

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Option	Selection
Feedback loop	“Mute audio input” should not be selected
Audio device Type	Windows Audio
Output	Speakers (Soundskrit Raw)
Input	Microphone (Soundskrit Raw)
Active Input Channels	Input channel 1 + 2 Input channel 3 + 4 Input channel 5 + 6
Sample Rate	48000 Hz
Audio buffer size	480 samples (10.0 ms)
Active MIDI Inputs	Leave empty

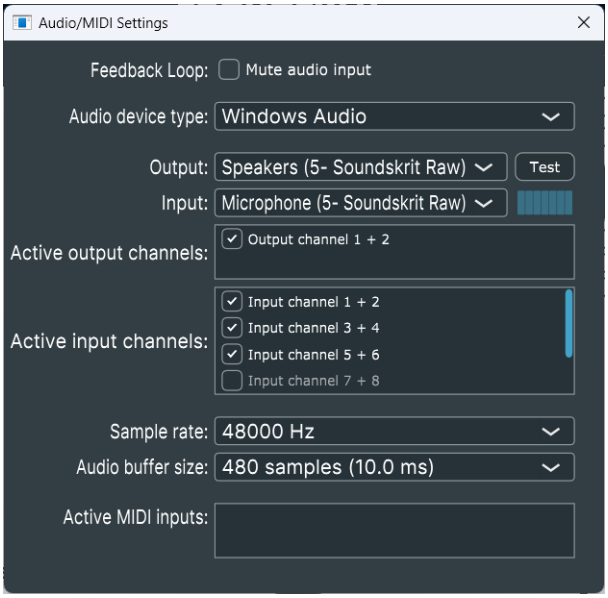

Figure 7: Properly configured options menu

Software Overview

In the bottom left, there are levels for each of the four microphones built into the Beetle. The microphones labelled ‘X’ and ‘Y’ are two orthogonal Soundskrit dipole microphones covering a horizontal plane. The Soundskrit dipole ‘Z’ is orthogonal to ‘X’ and ‘Y’ and covers the vertical plane. The omnidirectional microphone labeled ‘W’ captures sound equally from all directions.

At this stage, the blue input level bars should visibly respond to sound.

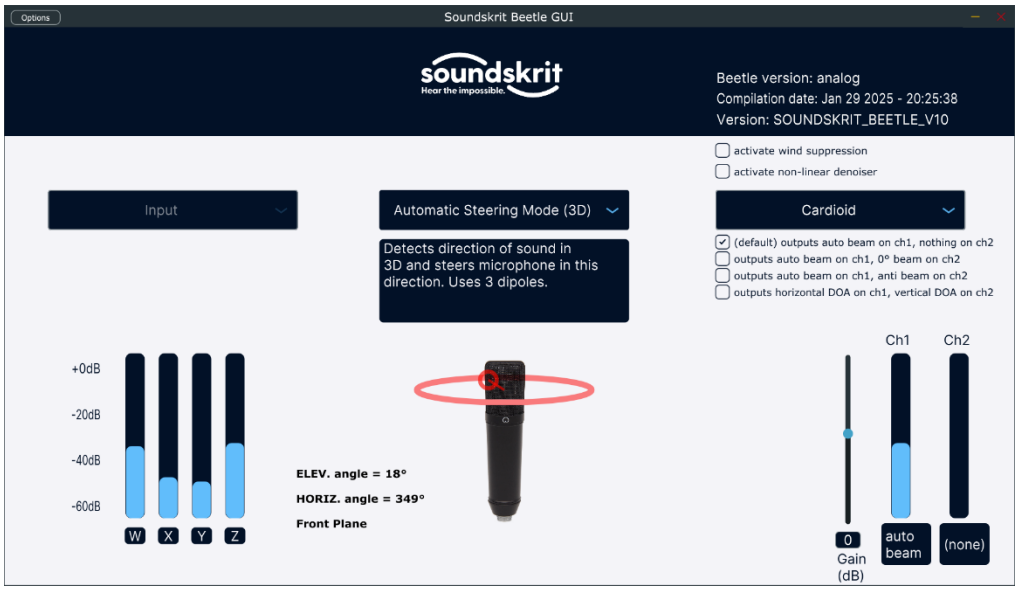

Figure 8: Input signal levels of the four microphones.

On the bottom right are the levels for the two output channels of the stereo output signal displayed. Next to these level indicators is a gain slider to adjust the output gain.

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Using the Software

In the top middle of the GUI is a dropdown menu allowing you to select which beamforming mode to use.

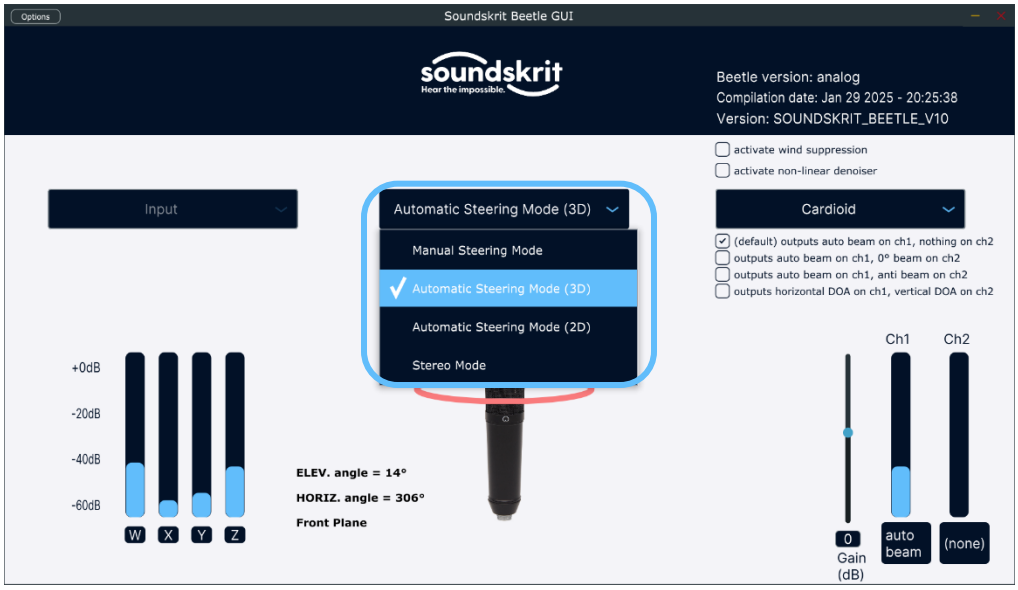

Figure 9: Selecting the beamforming mode.

In “**Manual Steering Mode**,” the microphones are combined to create a beam pattern which can be manually pointed in any direction by using the “Horizontal angle” slider, which steers the beam in any direction in the horizontal plane using angles from 0° to 360°. Use the “Vertical angle” slider to steer the beam to any elevation from -90° to 90°.

The microphone image in the center-bottom of the GUI illustrates the selected angle by placing a red circle in the direction of the beam.

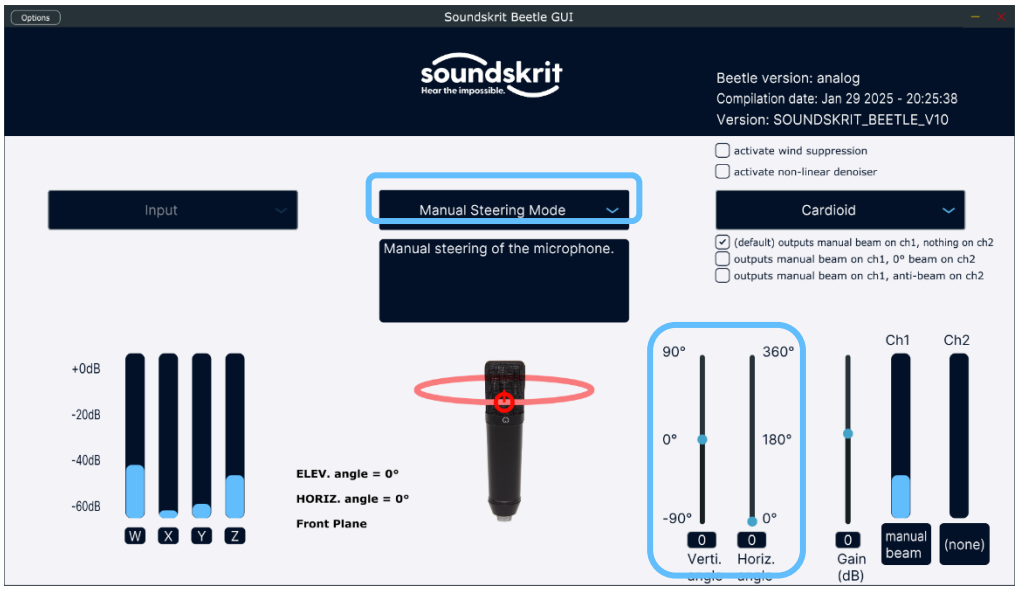

Figure 10: Manual steering the cardioid beam using a slider.

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In “**Automatic Steering Mode (3D)**”, the Beetle instantaneously detects the loudest sound from any direction, displays the horizontal and elevation angles in the image, and steers the beamformer in this direction.

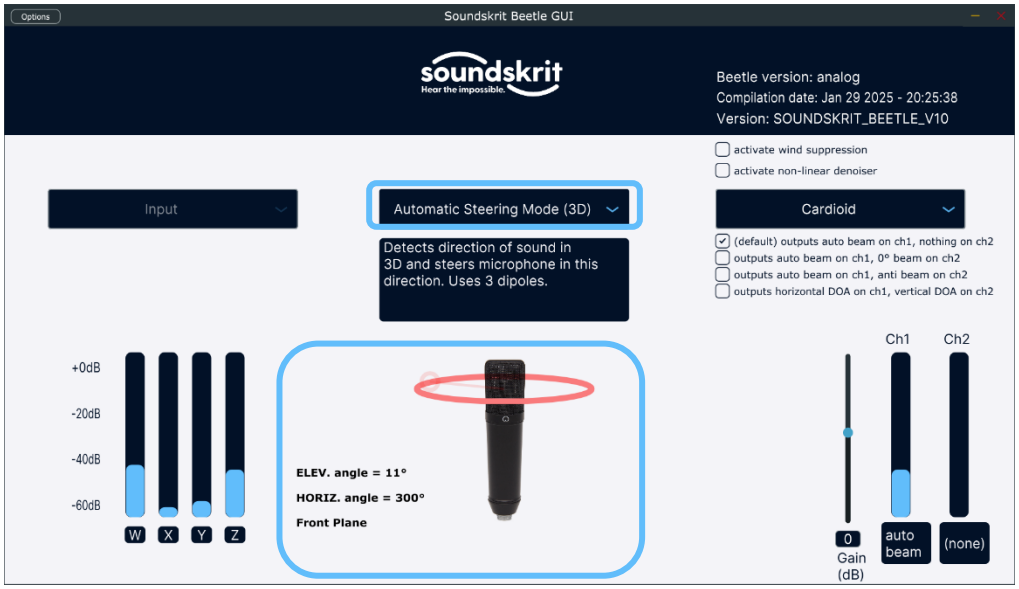

Figure 11: Automatic steering beam to the direction of sound in a 3D space.

The “**Automatic Steering Mode (2D)**” is like the 3D mode above but does not use elevation or vertical direction. The beam is steered only in a horizontal plane around the Beetle and dipole ‘Z’ is not used.

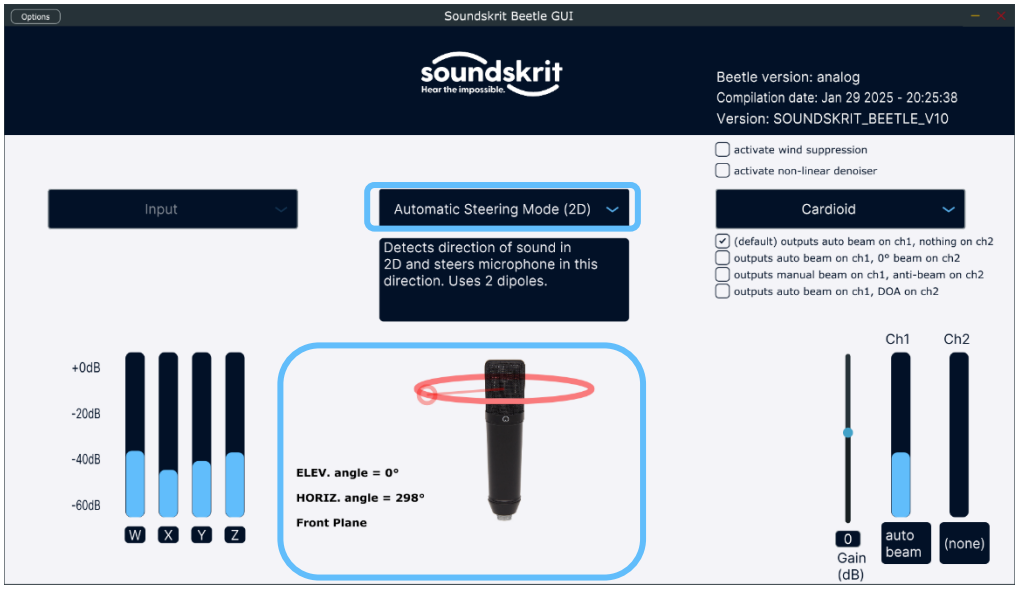

Figure 12: Automatic steering beam to direction of sound in a 2D plane.

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In “**Stereo mode**”, a stereo beam can be manually steered in the 3D field. Steering is done using the two sliders similar to the Manual Steering Mode described above, but the output signals are two directional beams: One on Channel 1 pointing at the selected angle -45°, the other on Channel 2 pointing at the selected angle +45°. When listening to the resulting stereo recording through headphones or a stereo speaker setup, an immersive stereo audio can be perceived.

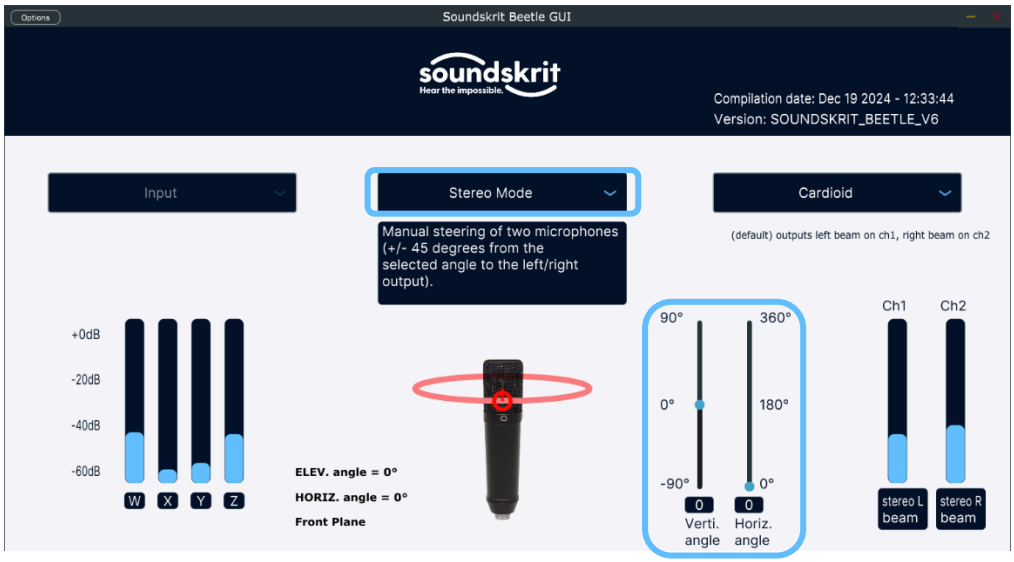

Figure 13: Stereo mode.

Advanced Functions

Changing the Beamforming Type

The right side of the GUI shows a beamforming type selector. The default output is a cardioid beam, other options include hypercardioid, dipole and omnidirectional.

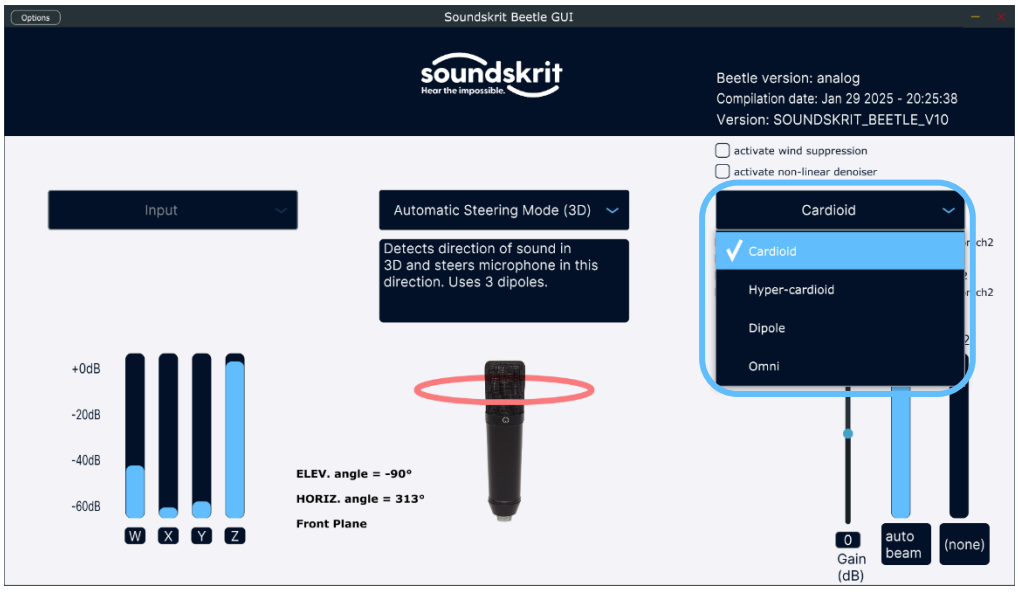

Figure 14: Automatic steering beam to the direction of sound.

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Beamforming Types

Cardioid Beamformer

The plots below show the cardioid beamformer's directivity, frequency response and noise. A cardioid picks up the least amount of sound from 180° and maximum from the front.

This mode can be used to capture a single speaker (or in auto mode steering to multiple speakers, one at a time) while rejecting ambient noise.

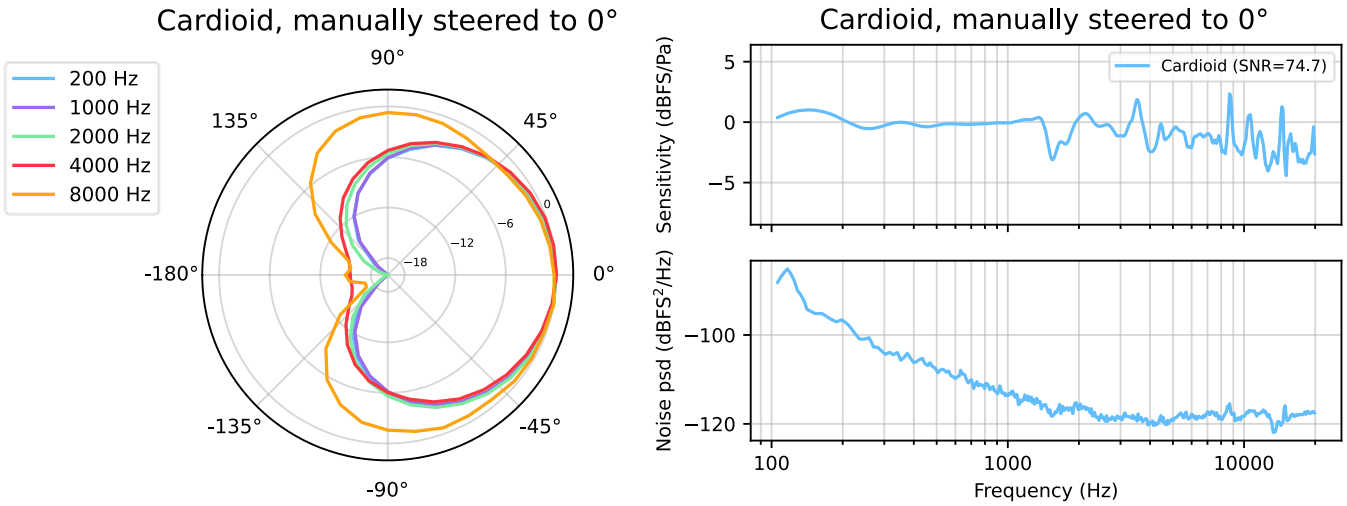

Figure 15: Polar plot (left) and Frequency response & Noise (right) of the cardioid beam.

Hypercardioid Beamformer

The plots below show the hypercardioid beamformer's directivity, frequency response and noise. A hyper-cardioid is narrower than a cardioid beam but has a small rear-lobe. The nulls where the highest attenuation is are at 110° and 250°.

This mode can is like the cardioid mode but has a narrower beam and more diffuse noise rejection.

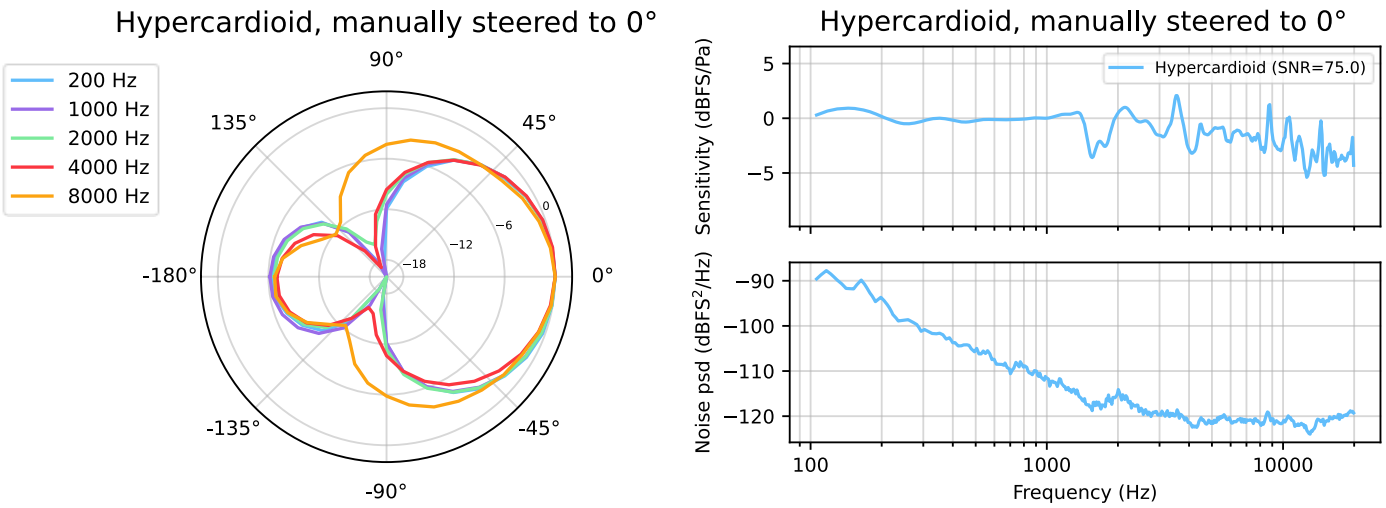

Figure 16: Polar plot (left) and Frequency response and noise (right) of the hyper-cardioid beam.

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Dipole Beamformer

The plots below show the dipole beamformer's directivity, frequency response and noise. A dipole has narrow beams to the front and rear and nulls at 90° and 270°. In this mode, the omnidirectional microphone is not used.

A dipole can be used in an interview situation when two speakers are on opposite side of the microphone, noise from other directions gets attenuated.

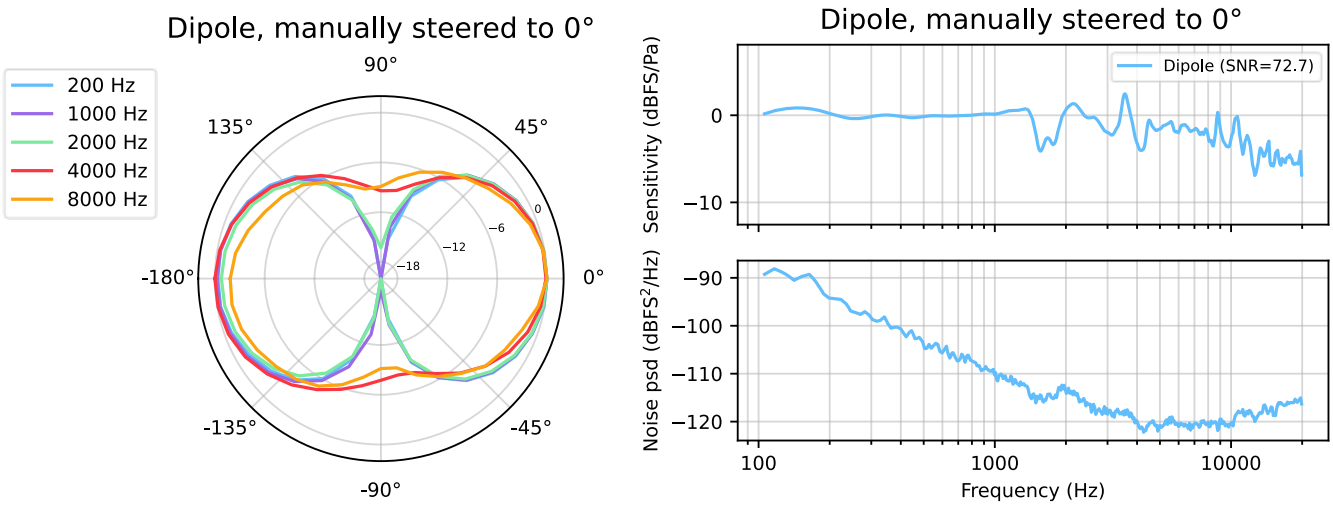

Figure 17: Polar plot (left) and Frequency response and noise (right) of the dipole beam.

Omnidirectional

This mode is only for comparison with the directional modes, only the omnidirectional microphone is used. An omnidirectional microphone picks up sound from all angles equally.

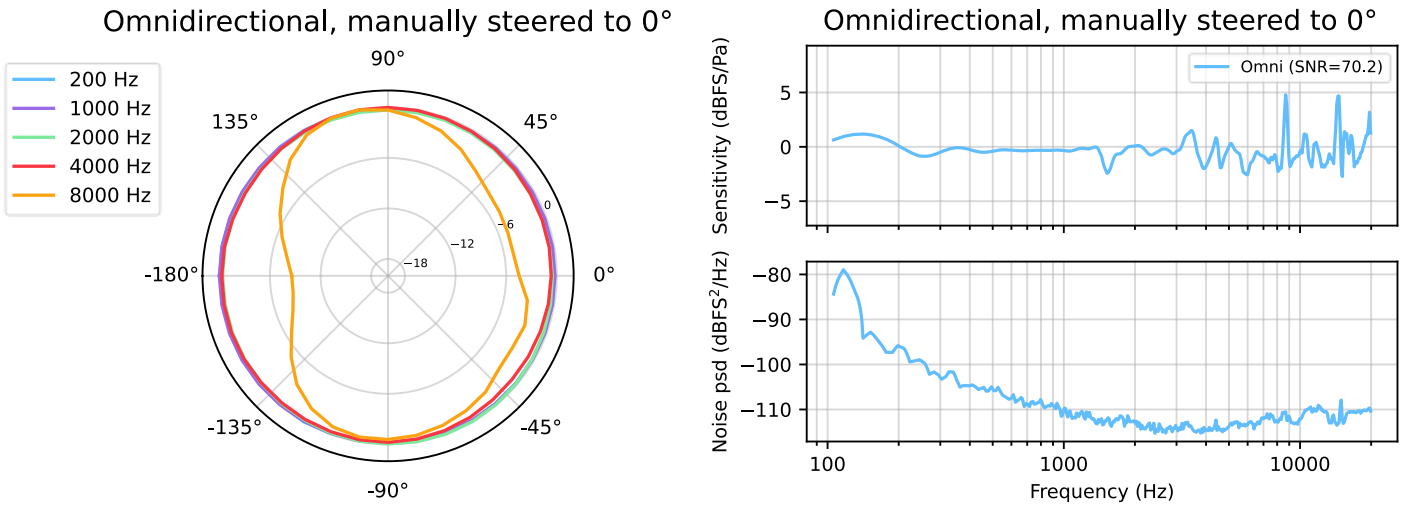

Figure 18: Polar plot (left) and Frequency response and noise (right) of the omnidirectional microphone.

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Recording Modes

Some steering modes offer additional options, such as recording a front-steered beam on the second stereo channel for comparison or embedding detected angles in the .wav file (horizontal angle is mapping 0° to 360° to the range of -1 to 1 in the audio file and vertical angle is mapping -90° to 90° to the range of -1 to 1 in the audio file). These additional modes can be selected by using the checkmarks below the beamforming selector.

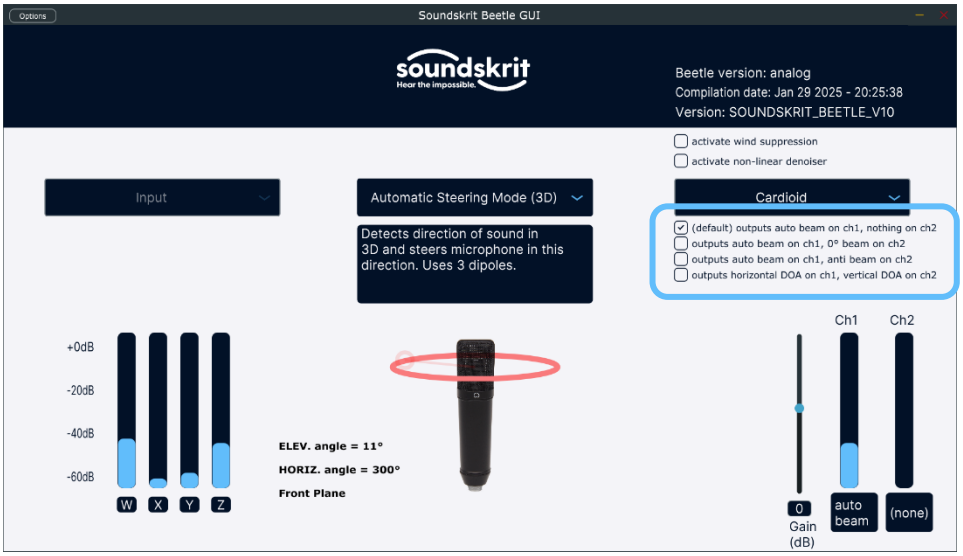

Figure 19: Recording mode selector checkmarks.

The following modes are available:

Manual Steering Mode:

- (Default) manual beam on channel 1; channel 2 muted
- Manually steered beam on channel 1; fixed beam to 0° on channel 2 for comparison
- Manually steered beam on channel 1; beam to the opposite side on channel 2

Automatic Steering Mode (3D):

- (Default) automatically steered beam on channel 1; channel 2 muted
- Automatically steered beam on channel 1; fixed beam to 0° on channel 2 for comparison
- Automatically steered beam on channel 1; beam to the opposite side on channel 2
- Audio-encoded detected angle: horizontal angle on channel 1; vertical angle on channel 2

Automatic Steering Mode (2D):

- (Default) automatically steered beam on channel 1; channel 2 muted
- Automatically steered beam on channel 1; fixed beam to 0° on channel 2 for comparison
- Automatically steered beam on channel 1; beam to the opposite side on channel 2
- Automatically steered beam on channel 1; audio-encoded detected horizontal angle on channel 2

Stereo Mode:

- (Default) manual left beam -45° on channel 1, right beam +45° on channel 2

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Nonlinear denoiser

In all modes except the stereo mode, a nonlinear denoiser can be activated by enabling the checkmark on the top right. This results in a higher noise rejection for sound coming from outside the selected beamformer but might introduce some processing artefacts. Activate this option for the highest noise rejection, disable it for a more natural sound.

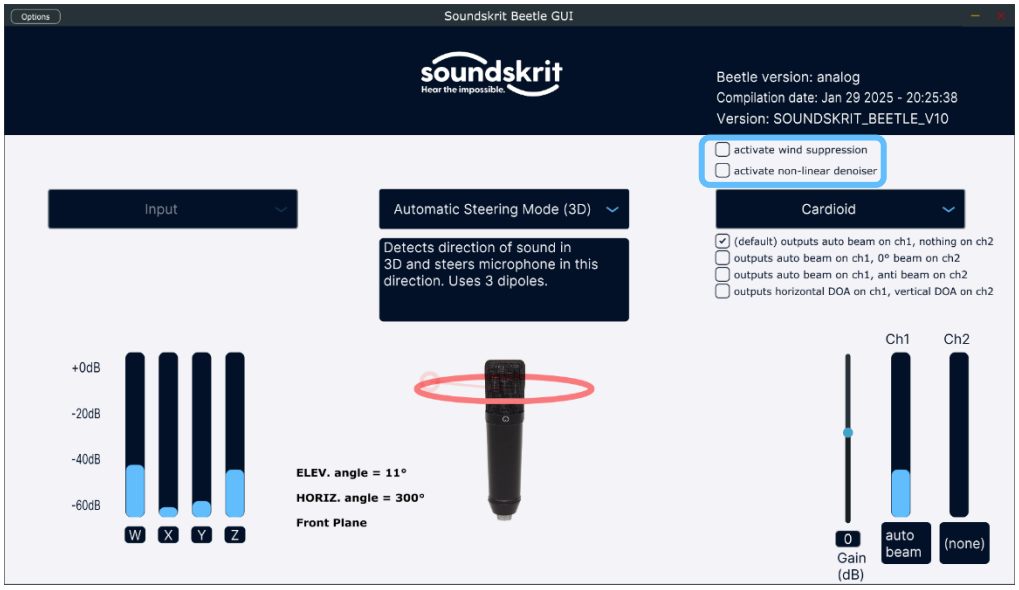

Figure 20: Nonlinear denoiser and wind noise suppression options.

Wind noise suppression

If required, a wind noise suppression can be enabled through a checkmark in the top right corner. This option is not available in stereo mode.

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Recording Audio with the Beetle

To record audio with the Beetle demo kit, we recommend installing Audacity. Audacity is a trusted, free to use, multiplatform suite of tools for recording and working with audio files.

Once you have installed Audacity, we need to configure the software for use with Soundskrit's audio interface. Configure the settings as listed below:

Audio Host	Windows WASAPI
Input[1]	*Speakers (Soundskrit Raw) Loopback* – Ensure the loopback version of the driver is selected
Output	Your listening device
Channels	2 (Stereo) Recording Channels

[1]Audacity has two versions of each input option, the regular and the loopback, to use our software correctly the loopback mode must be selected. If this is configured correctly, there will be two recording channels listed, while the non-loopback will allow up to 6. Loopback is typically the first of the two versions.

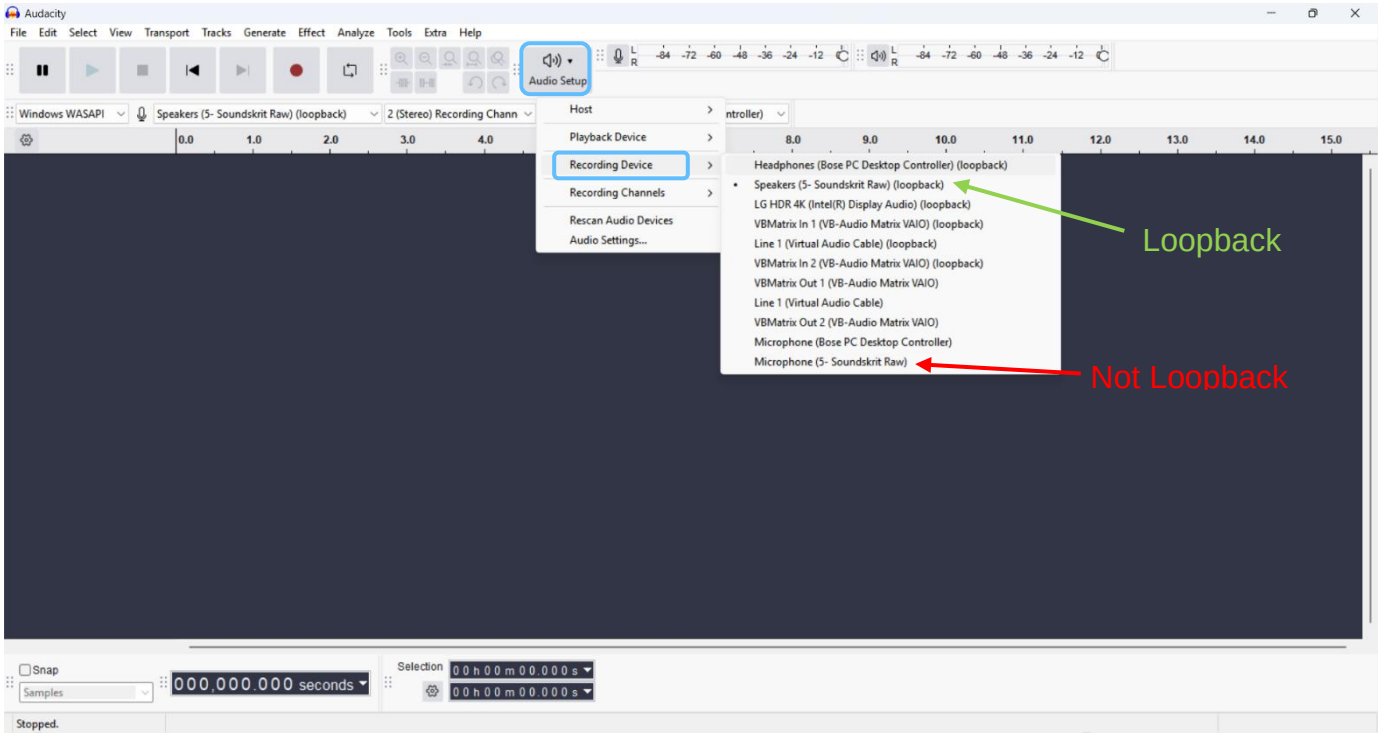

Figure 21: Properly Configured Audacity

To start recording, press the record button. Press stop when finished.

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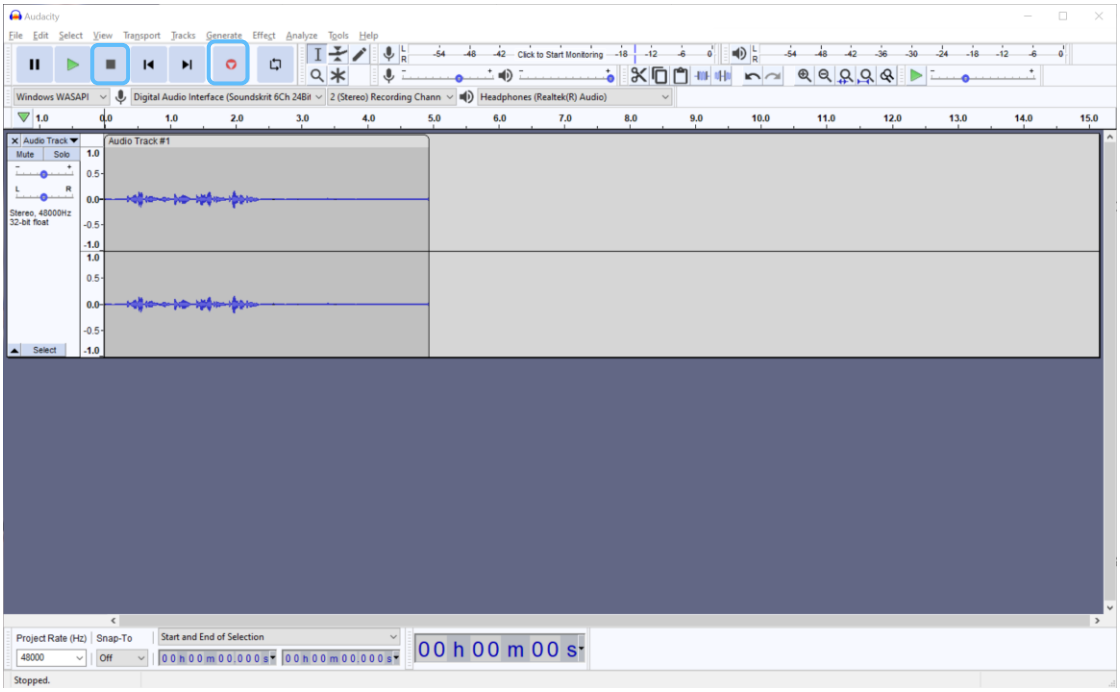

Figure 22: Recording in Audacity.

To listen to only one of the two signals, we need to split the stereo track to listen to them independently. To do this, right click *Audio Track* and select *Split Stereo to Mono.*

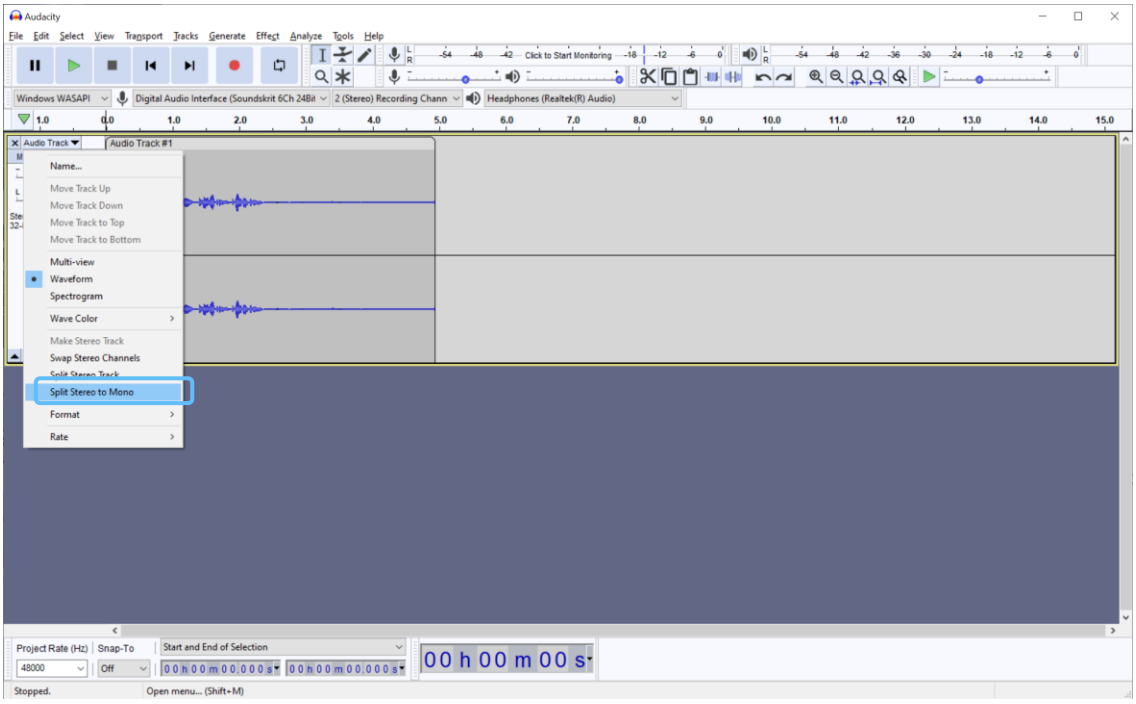

Figure 23: Splitting stereo to mono.

Once you have split the stereo track, you can listen to either track by selecting *solo* and pressing the space bar or play button. In Audacity, the top track corresponds to channel 1 in our software and the bottom track to channel 2 in our software.

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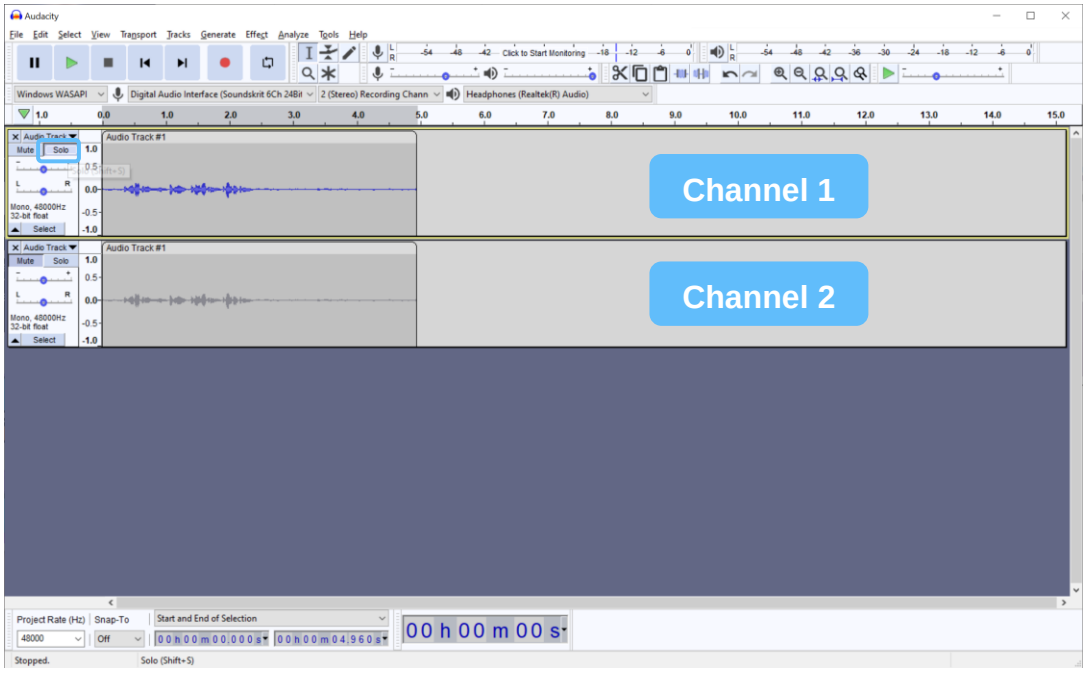

Figure 24: Playing back individual tracks.

Raw Microphone Recording

To record the four raw microphone signals, select input "*Microphone (Soundskrit Raw)"* (NOT loopback) and choose 12 recording channels in Audacity. The channel routing is as follows:

Recording channel	Microphone
1	Dipole Z-axis
2	Omnidirectional (W)
3	Dipole Y-axis
4	None
5	Dipole X-axis
6-12	None

Additional Support

For further information on Soundskrit's products, visit our website at http://www.soundskrit.ca where you can find more application notes, datasheets, and purchasing information. If you have any questions or need technical support, please reach out to applications@soundskrit.ca.

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Revision History

Revision Label	Revision Date	Sections Revised
-	May 2024	Initial release
A	June 2024	Added kit description and other clarifications
B	June 2024	Added stereo mode
C	July 2024	Mic shell added
D	September 2024	Updated GUI screenshots
E	January 2025	Added Z-direction DOA and beam steering, added different beam pattern options, added audio-encoded output of detected DOA, updated GUI v6
F	February 2025	Minor changes, typos, wording, formatting
G	February 2025	Updates for GUIv10, introducing nonlinear beamforming and wind noise suppression
H	March 2025	Updated to prototype with PDM microphones, from analog microphones in previous versions, Updated measurement plots

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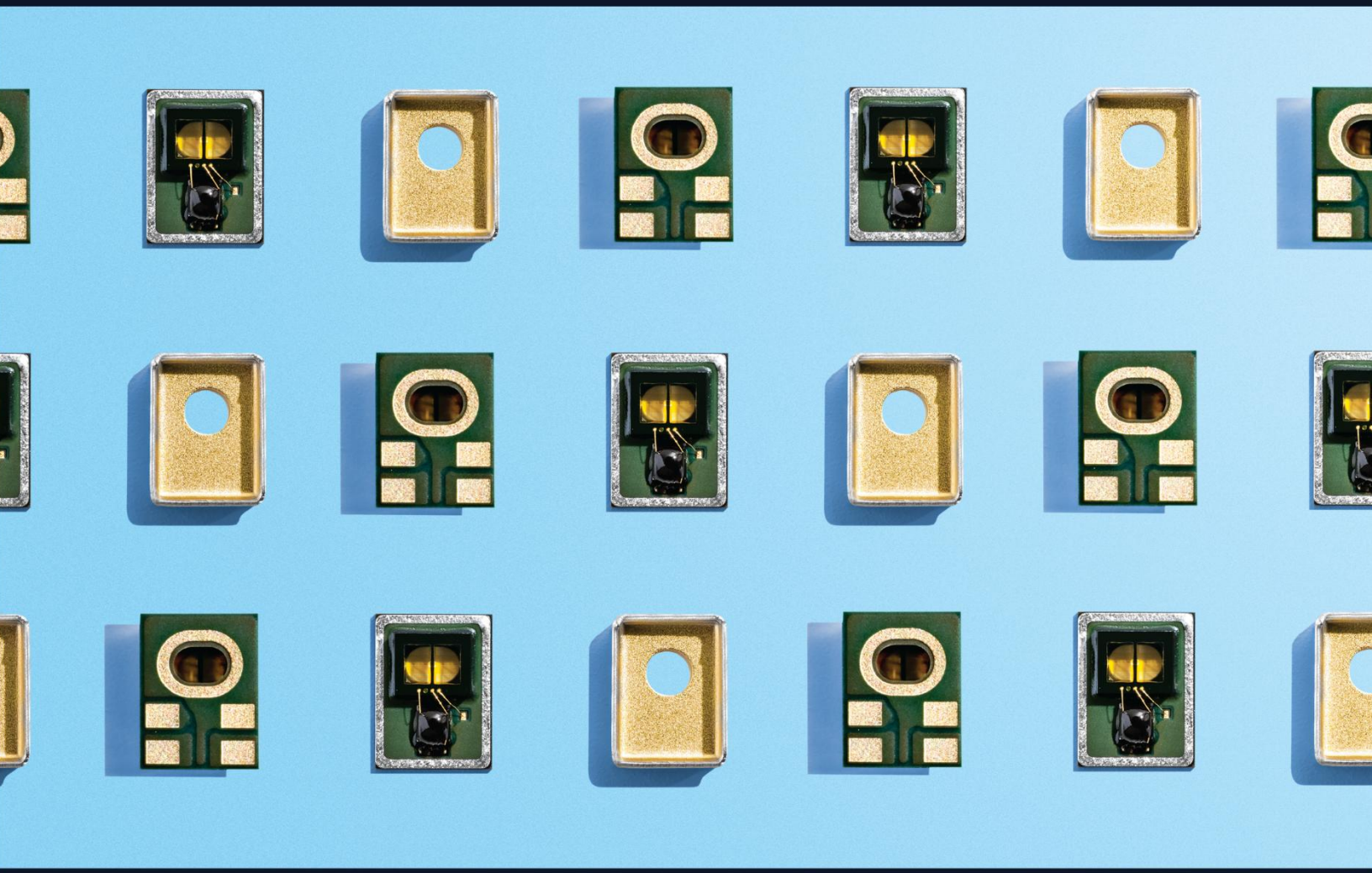
Soundskrit developed the first high-performance directional MEMS microphone on the market, leveraging years of research in bio-inspired MEMS based on how spiders and other insects in nature hear. In combination with Soundskrit's in-house audio processing algorithms, directional microphones can be used to capture and isolate any sound in an environment with a fraction of the size, power, and computation of traditional omnidirectional-based microphone arrays.

Soundskrit was founded in 2019 and is headquartered in Montreal, Quebec with an R&D facility in Ann Arbor, Michigan.



soundskrit
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