

# VIRTUOSO

Powered by **ASPEN**<sup>™</sup>

v2.0.0

## USER MANUAL



Last updated: 3 Oct 2024

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# 1 INTRODUCTION

Thank you for choosing Virtuoso, a cutting-edge binaural monitoring tool powered by ASPEN™. Virtuoso virtualises stereo or immersive loudspeaker setups and professional quality listening rooms for headphone monitoring, and offers excellent tonal/spatial fidelity and a highly accurate translation to real loudspeakers. It will allow you to mix on headphones with confidence.

The key benefits you can enjoy with Virtuoso are:

- Realistic virtual immersive mix/listening rooms, which can be customised acoustically for your own or other rooms.
- Effective externalisation and accurate localisation of virtual loudspeakers – essential for making correct mix decisions on headphones.
- Excellent tonal naturalness – just like listening to premium loudspeakers in real life.
- Highly accurate translation to real loudspeakers.
- Less headphone listening fatigue.

The main features of Virtuoso include:

- 53 multichannel input configurations from mono to 26 channels, supporting all popular immersive audio formats, e.g. ITU-R, Dolby Atmos, Auro-3D, MPEG-H and regular arrays for Ambisonics.
- Seven presets of scientifically tuned virtual rooms.
- Customisable acoustic parameters.
- Head tracking (OSC and manual).
- Routing matrix with solo, mute and level controls.
- Downmix options.
- Five HRTF sets and SOFA file loading.
- Headphone compensation EQ (100 models and custom profile loading).
- 10-band parametric EQ for customising headphone EQ profiles.
- Loudspeaker emulation EQ (11 models).
- WAV/ADM file playback (Standalone only).

## 2 ACTIVATION

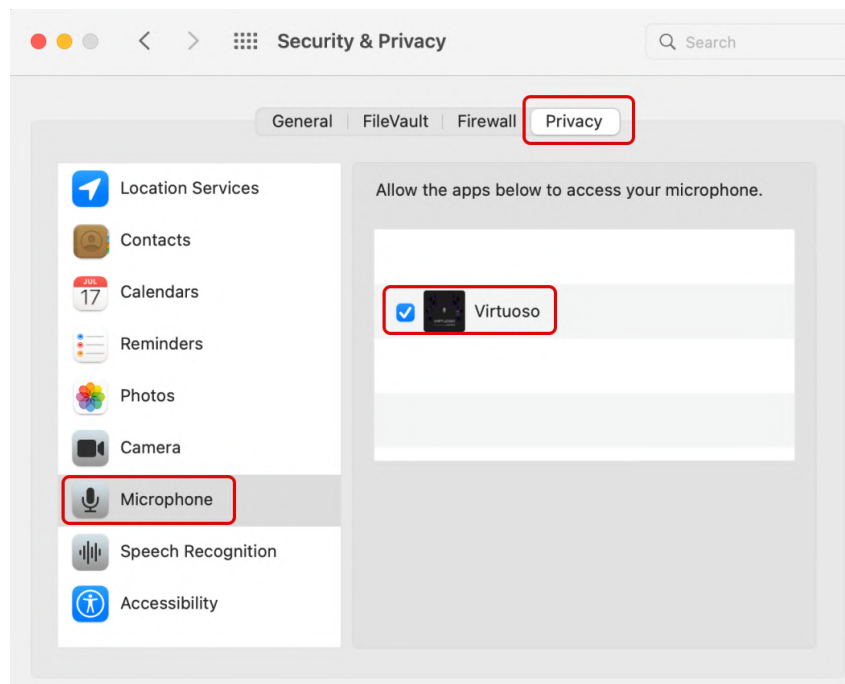
Virtuoso is activated via iLok. Once you have checked out Virtuoso on our website, you will receive an email including the licence code and software download link. To activate Virtuoso, you need to redeem the code on the iLok License Manager software, which you can download from <https://www.ilok.com/#!license-manager>. There are two activation methods available: iLok dongle (gen 2 or 3) and computer. If you activate it on an iLok dongle, you can connect it to and use Virtuoso on any computer that the software has been installed on. If the licenses is activated directly on your computer, you can use Virtuoso only on that machine.

Executing the installer file (.pkg for Mac OS and .exe for Windows) will automatically install Virtuoso in the default plugin folder:

- Mac OS: Macintosh HD/Library/Audio/Plug-Ins (VST3 and Components for AU)
- Windows: C:\Program Files\Common Files\VST3

**Note:** For the Virtuoso Standalone app for macOS, you need to allow it to access microphone (i.e. audio input) in System Preferences - Security & Privacy - Microphone

For setting up the standalone app with a virtual audio driver, see Section 5.

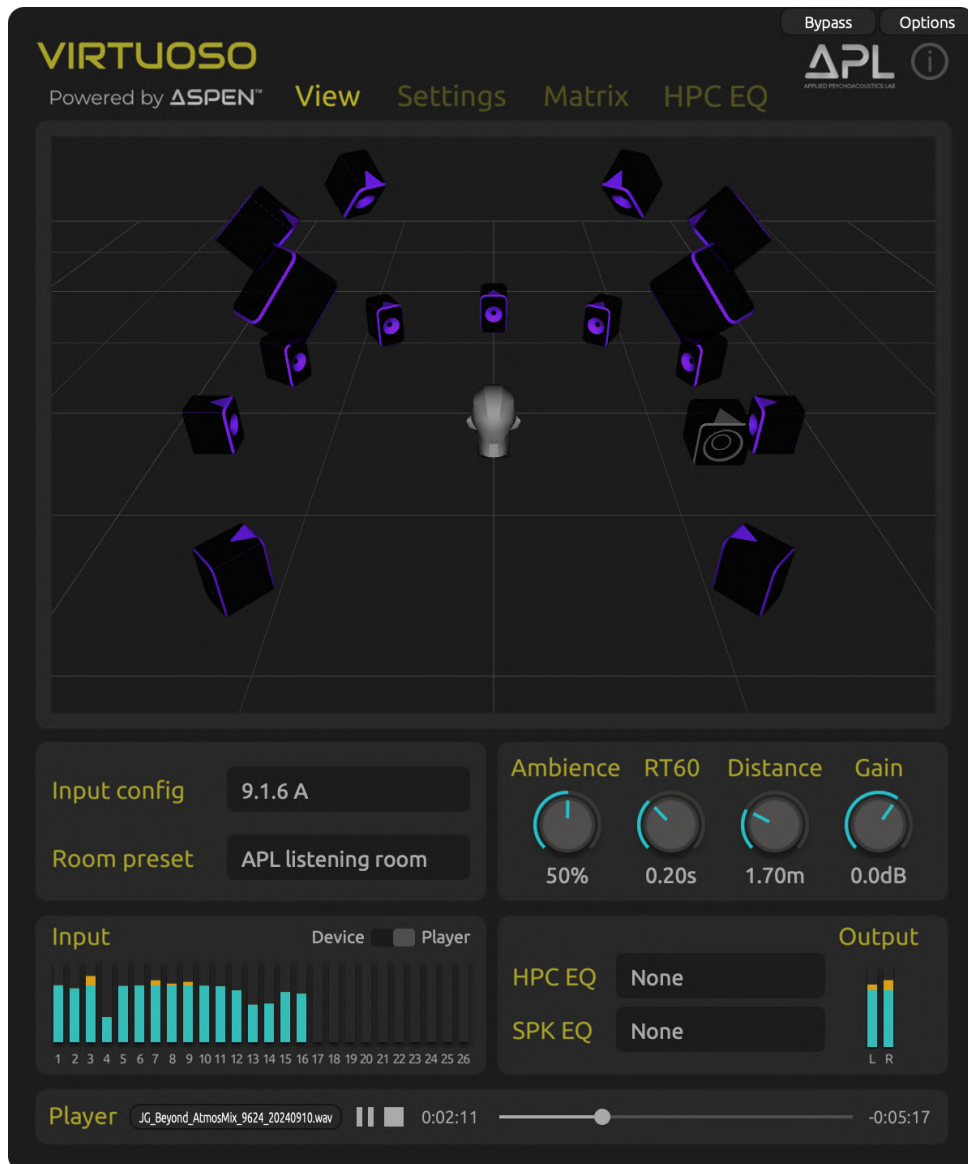


### 3 OVERVIEW

Virtuoso has a simple and intuitive graphical user interface (GUI). The front panel comprises the main control knobs and configuration menus that will get Virtuoso up and running quickly. There are three tabs: View, Settings and Matrix. The View simply visualises the positions of the loudspeakers of the selected input configuration, the Settings provide you with advanced controls and the Matrix allows you to change input/output channel mappings and the levels of input signal feeding the loudspeakers.

#### 3.1 Front Panel

The front panel consists of Input config, Room preset, Ambience, RT60, Distance, Gain, HPC EQ, SPK EQ as well as the Input and Output level meters. The Standalone version includes WAV/ADM Player.



**Note:** Player is a feature only available in the standalone version.

##### 3.1.1 Input config

The Input Config menu allows you to choose a virtual loudspeaker array for your input configuration. This gives you the freedom to mix stereo or immersive audio on headphones wherever you are.

Even if you do not have real loudspeakers, you can already create immersive audio using the virtual loudspeakers that would be localised highly accurately. A total of 53 input configurations are currently supported, including all popular formats such as Stereo, Mono, ITU-R, Dolby Atmos, Auro-3D, MPEG-H, NHK 22.2 as well as regular speaker layout for Ambisonic reproduction up to 26-channels. The channel order and loudspeaker layout used for each input configuration can be found in Section 6 of this document and on the web link: <https://apl-hud.com/apl-virtuoso-loudspeaker-layouts/>

**Note:** Some Dolby Atmos and Auro-3D configurations have separate versions for Logic Pro, Nuendo and Pyramix, which use different channel orders or/and labelling conventions. If you use any of these DAWs, please choose an input config dedicated to the DAW, e.g. Dolby Atmos 7.1.4 Logic Pro.

### 3.1.2 Room preset

Room plays a critical role on the accuracy of sound localisation and externalisation as well as perceived tonal balance. Just processing your stereo or multichannel signals with a set of HRTF would give you an impression of listening to the sound in an anechoic chamber, which is unrealistic. Even for a conventional stereo listening, headphones give you a very different spatial and tonal presentation. To make your mix done on headphones translate well to real loudspeakers in your own or different rooms, therefore, it is necessary to simulate a reference listening room in headphone monitoring.

Virtuoso provides you with seven presets of virtual listening rooms that have been scientifically designed with ASPEN™'s 3D geometric acoustic simulation and carefully tuned by Tonmeister ears. The APL Listening Room preset models the actual APL's critical listening room that complies with the ITU-R BS.1116-3 recommendations. All of the preset rooms have different room dimensions and acoustic characteristics.

### 3.1.3 Ambience

The Ambience knob controls the overall level of room sounds (early reflections and reverberation). The 50% default position will give you a good starting point. Try adjusting it to find a sweet spot for you. The flexibility of controlling the amount of ambience is important because the perceived naturalness and realism of binaural sounds depends significantly on how well the level of ambience in the physical room you are in matches that in the virtual room you are listening to over headphones, among other factors. This influences both externalisation and localisation, as well as tonal naturalness. For example, if you are in an acoustically lively space, then more ambience might be required to give a similar level of distance perception and tonal similarity in binaural reproduction. Conversely, if your room is relatively dry, you may not need as much ambience.

### 3.1.4 RT60

This is the reverb time control. RT60 refers to the time taken for the sound level to decay to -60 dB as reference to the initial onset of the sound. The range of the RT60 knob is from 0.1 to 0.4 seconds.

**Note:** Virtuoso is not designed to be a reverberator, but to simulate a realistic listening environment. Most controlled mixing studios would likely have an RT60 between 0.2 to 0.4s.

### 3.1.5 Distance

This is a knob to control the loudspeakers-to-listener distance. Changing the physical distance would influence the perceived distance of the sound generated from the loudspeakers. All the virtual loudspeakers of an input config are equidistant from the listener. For this reason, the maximum distance that can be set is currently limited based on the minimum dimensions of the room.



### 3.1.6 Gain

This is to control the final 2-channel binaural output level.

### 3.1.7 HPC EQ

For the most accurate presentation of head-related transfer function (HRTF) in binaural audio rendering, it is often necessary to make the frequency response of the headphones perceptually “flat”. For this purpose, Virtuoso currently provides Headphone Compensation Equalisation filters for 100 popular models. The filters were taken and modified from the AutoEQ database (MIT license – see Section 7). The loaded EQ profile can be customised using the new 10-band parametric equaliser in the HPC EQ tab.

**Note:** These EQs are not to emulate the spectral colours of the headphones, but to neutralise the colours.

v2.0.0 introduces a new feature that allows you to load **custom HPC EQ** .txt files. You can find different EQ profiles for your headphone models from the AutoEQ library. Once you have loaded a custom HPC EQ file, it will be stored in the "custom" option and recalled when you open the plugin or app next time.

None	Audeze Maxwell	Beyerdynamic T1	Grado SR325e	Shure KSE1200
AKG K240 MKII	Audeze MM-100	Beyerdynamic T5	HEDD HEDDphone	Shure KSE1500
AKG K240 Studio	Audeze MM-500	Bose NC Headphones 700	HIFIMAN Ananda Nano	Shure SE535
AKG K371	Audeze Mobius	Bose QuietComfort 25	HIFIMAN Arya	Shure SE846
AKG K612	Audio-Technica ATH-M20x	Bowers & Wilkins P5	HIFIMAN Arya Stealth	Shure SRH840
AKG K702	Audio-Technica ATH-M30x	Bowers & Wilkins PX	HIFIMAN Edition XS	Shure SRH1540
AKG K712	Audio-Technica ATH-M40x	Bowers & Wilkins Px8	HIFIMAN HE400i	Sony MDR1000X
Apple AirPods Max	Audio-Technica ATH-M50x	Dan Clark Audio Stealth	HIFIMAN HE400se	Sony MDR7506
Apple AirPods	Audio-Technica ATH-M60x	Etymotic ER4XR	HIFIMAN HE1000se	Sony MDR-Z1R
Apple AirPods Pro	Audio-Technica ATH-R70x	Focal Bathys	HIFIMAN Sundara	Sony WH-1000XM4
Apple AirPods Pro2	Austrian Audio Hi-X55	Focal Celestee	HIFIMAN Susvara	Sony WH-1000XM5
Apple EarPods	Austrian Audio Hi-X60	Focal Clear	Neumann NDH20	Stax Lambda Nova Basic
Audeze CRBN	Austrian Audio Hi-X65	Focal Clear Mg	Neumann NDH30	Stax SR-007
Audeze LCD-1	Avantone Planar	Focal Elegia	Philips SHP9500	Stax SR-009
Audeze LCD-2	Bang & Olufsen Beoplay H9	Focal Elex	Sennheiser HD25-1 II	Stax SR-L500
Audeze LCD-3	Bang & Olufsen Beoplay H95	Focal Utopia	Sennheiser HD560S	Stax SR-Lambda Pro
Audeze LCD-4	Beyerdynamic DT770 250 Ohm	Focal Utopia 2022	Sennheiser HD600	Ultrasono PRO 900
Audeze LCD-4z	Beyerdynamic DT880 250 Ohm	Grado GW100	Sennheiser HD650	Load...
Audeze LCD-GX	Beyerdynamic DT990 250 Ohm	Grado RS2	Sennheiser HD660S	Custom
Audeze LCD-MX4	Beyerdynamic DT1770	Grado SR60e	Sennheiser HD800	
Audeze LCD-X	Beyerdynamic DT1990	Grado SR225e	Sennheiser HD800S	

### 3.1.8 SPK EQ

Also provided are the Loudspeaker (SPK) EQ filters that model the free-field on-axis frequency responses of 11 near-field monitor loudspeakers listed below. Unlike usual parametric EQs, SPK EQs emulate the complex and unique frequency response of the loudspeakers. Therefore, they allow you to choose virtual loudspeakers with different spectral balances for your monitoring purposes but also can be used for adding a unique tonal colour to your native binaural mix. More headphones and loudspeaker EQs will be added in future updates.

(A) ATC SCM11 (B) ATC SCM7 (C) Barefoot MM45 (D) BW 705 S2 (E) Dutch and Dutch 8C (F) Genelec 8331A (G) Harbeth M30.2 XD (H) Nuemann KH120A (I) PMC6 (J) Q Acoustics 3030i (K) Yamaha HS5

**Note:** The frequency response of a loudspeaker depends on the frequency and measurement position and most near-field loudspeakers have limited low-end response. The SPK EQs are designed to emulate only the on-axis response above around 250Hz, thus maintaining the original low-end extension of the default (None) setting.



### **3.1.9 Input and output level meters**

The division point between the blue and yellow bars indicate -18 dBFS.

### **3.1.10 Player**

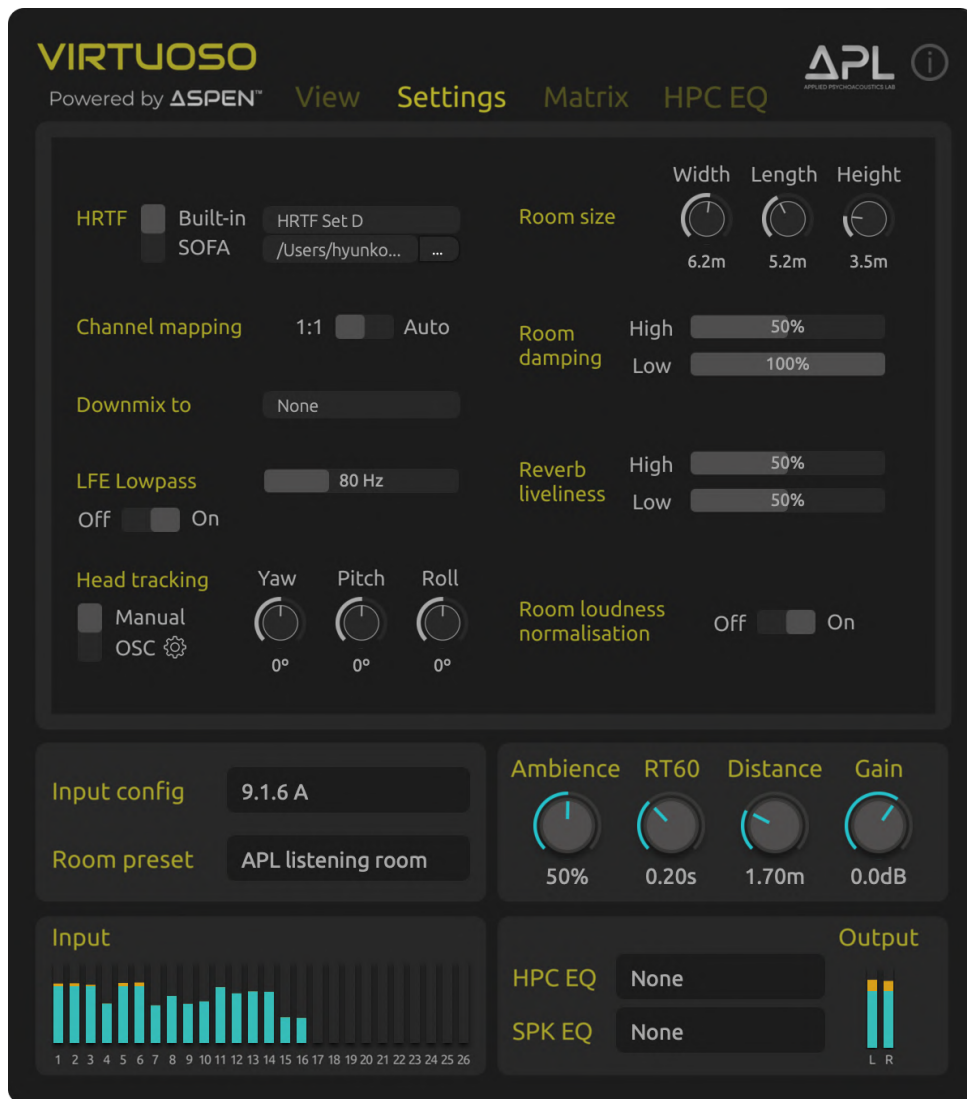
This feature is available only in the the Standalone app version. You can load stereo or multichannel WAV files, including BW64 ADM files. To activate it, select Player in the Input section; Device needs to be selected for feeding audio via a virtual audio device. When you load a normal multichannel WAV file, e.g., 12ch with the Atmos 7.1.4 channel order, you need to choose the corresponding Input Config (e.g., Atmos 7.1.4). If you choose an input config that uses less channels than the WAV file, then only the channels available for the input config will become active. However, if you load an ADM WAV file, Virtuoso will decode the ADM metadata and render multichannel outputs that follow the input config selected. For example, if the ADM file includes 8 channels and 120 objects, and you select Atmos 7.1.4A, then it will be rendered to 12 channels of output signals for the input config.

## **3.2 View**

v2.0.0 introduces the interactive 3D view tab. You can rotate the view vertically by moving the mouse up and down while left-clicking, and zoom in or out the view by scrolling the mouse up and down. You can also solo or mute each loudspeaker by right-clicking over the loudspeaker.

## **3.3 Settings**

The Settings tab gives you advanced options for customisation and head tracking.



### 3.3.1 HRTF

Head-related transfer function (HRTF) is the aural fingerprint that allows humans to perceive the direction of arrival of a sound in three-dimensions (front/back and up/down as well as left/right). Virtuoso allows you to choose either one of the three built-in HRTF sets or a custom-made HRTF set written in SOFA (Spatially Oriented Format for Acoustics).

**Built-in:** The five built-in HRTF sets A, B, C, D and E were carefully chosen and tuned from open-access databases from the University of York, TH Köln University of Applied Science and Meta Reality Labs. They offer distinct tonal and spatial differences, and you may find one set more effective and natural-sounding to your ears. The HRTF sets A and B are based on the GRAS KEMAR and Neumann KU-100 head-related impulse responses (HRIRs) from the York's SADIE II database (licensed under Apache license version 2.0), respectively. The HRTF C is based on KU-100 HRIRs from TH Köln (licensed under CC-BY 3.0 Unported). HRTF D and E are respectively based on the B&K HATS and GRAS KEMAR datasets from Meta Reality Labs (licensed under CC-BY 4.0). See Section 7 for license details.

**SOFA:** SOFA is a file format for storing spatially oriented acoustic data such as HRIRs and binaural impulse responses (BRIRs). Personalised or any custom-made HRTF sets written in a SOFA file can be imported into Virtuoso. More information about SOFA and a number of open-access SOFA HRTF sets are available at <https://www.sofaconventions.org>.

### 3.3.2 Channel mapping

With DAWs embracing spatial audio workflows, they are now often seen providing audio tracks that are optimised for spatial audio playback formats, e.g. 7.1.4, 9.1.6, 22.2 etc. However, we found that different platforms and software present their channel order to the plugin in a non-standard way. This poses a problem when rendering spatial audio formats binaurally using Virtuoso and other similar third-party plugins, where different channels may be rendered by the incorrect virtual loudspeaker. To solve this issue, we added the "Channel Mapping" function so that the channels presented by the DAW to Virtuoso get automatically mapped to the correct location.

There are two modes to Channel Mapping: 1:1 and Auto. In 1:1 mode, the channels get mapped in order to each input of Virtuoso in a sequential 1-by-1 fashion. This is the recommended mode for those who are working with Ambisonics, or find that their particular DAW of choice operates in this way (e.g. Reaper). In Auto mode, the channel names are then used to map each channel to a corresponding virtual loudspeaker. This is the recommended mode for those working with spatial audio layouts such as Dolby Atmos, Auro 3D, 22.2 etc.

### 3.3.3 Downmix

Your mix may sometimes need to be downmixed to a lower-channel-count format (e.g. stereo to mono, 5.1 to stereo, 7.1.4 to stereo, etc.) depending on the user's system. The Downmix function in Settings allows you to quickly check how your mix would sound in downmix scenarios. For a chosen input config (e.g. Atmos 7.1.4), options to choose downmix matrices for lower-channel configs (e.g. 5.1.4, 7.1, 5.1, stereo, mono) are provided. Upon your selection of a downmix config, the Matrix tab presents the downmix gains (in dB) applied to each signal of the original input config. You can also change the preset gain values and use different channels to create your own downmix matrix. See Section 3.3 for details about how to use the Matrix.

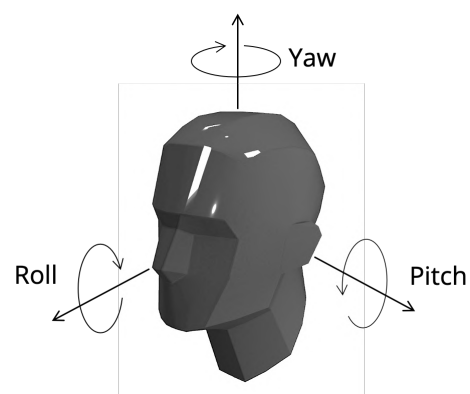
### 3.3.4 LFE Lowpass

This option allows you to control the low-pass filter cut-off frequency for feeding a signal to the LFE channel (i.e. subwoofer). Select Off if your LFE channel signal has already gone through a low-pass filter.

### 3.3.5 Head tracking

Head tracking can improve the sense of realism as well as the accuracy in localisation and externalisation. Virtuoso provides manual or OSC (open sound control) options for 3-degrees-of-freedom head tracking (Yaw, Pitch and Roll).

For OSC, three preset profiles (APL, IEM and Nxosc) are provided. The Bridgehead head tracker by Supperware (<https://supperware.co.uk/headtracker>) supports the APL and IEM profiles. The Nxosc profile allows you to use the Waves Nx headtracker, but this requires you to use a free bridge software called Nxosc (<https://https://audiooo.com/nxosc>).



### 3.3.6 Room size

This option allows you to customise the dimensions (width, length and height) of the virtual room up to 10m for each.

### 3.3.7 Room damping

You can control the overall amount of low and high frequency absorptions using the sliders.

### 3.3.8 Reverb liveliness

These sliders allow you to shorten or lengthen the reverb decay for low and high frequencies.

### 3.3.9 Room loudness normalisation

When this function is turned on, Virtuoso normalises the output level that would otherwise change when varying room dependent parameter values (especially the size of the room or the loudspeaker-to-listener distance); e.g. the levels of reflections increase as the room size gets smaller or the direct sound level relative to reflections increases as the loudspeaker distance decreases.

## 3.4 Matrix

This tab displays the routing matrix for input signals and virtual loudspeakers. The input columns follow the channel order of your input signals (e.g. a multichannel wav file or individual tracks routed into Virtuoso). The loudspeaker rows follow the standard channel order of the loudspeaker layout selected in Input config.

The Solo button allows you to monitor a specific virtual loudspeaker output. The Mute button mutes the virtual loudspeaker. You can also turn the input signals off/on by clicking each cell.

By clicking Solo or Mute while holding the "Shift" key, you can turn off the previous solo or mute as you solo/mute to another virtual speaker. i.e. X-OR in Pro Tools.

The gain (in dB) of each input signal can be changed between -inf to 12 dB by holding the **Shift** key and dragging the number by a mouse.

**VIRTUOSO**  
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Input

			1	2	3	4	5	6	7	8	9	10	11	12
Loudspeaker	L	S M	0.0											
	R	S M		0.0										
	C	S M			0.0									
	LFE	S M				0.0								
	Lws	S M					0.0							
	Rws	S M						0.0						
	Lss	S M							0.0					
	Rss	S M								0.0				
	Lrs	S M									0.0			
	Rrs	S M										0.0		
	Ltf	S M											0.0	
	Rtf	S M												0.0

Input config: 9.1.6 A  
Room preset: APL listening room

Ambience: 50%  
RT60: 0.20s  
Distance: 1.70m  
Gain: 0.0dB

Input:

HPC EQ: Maxwell  
SPK EQ: None  
Output: L R

**Note:** When you downmix the current input config to a specific config in the Downmix menu in the Settings tab, the Matrix view will show the mapping of the input channels to the downmix speaker config and the gain values (in dB) used for downmixing.

**VIRTUOSO**  
Powered by **ASPEN™** View Settings Matrix HPC EQ **APL** APPLIED PSYCHOACOUSTICS LAB

HRTF: Built-in SOFA, HRTF-Set A, Load SOFA File

Room size: Width 4.6m, Length 6.1m, Height 3.0m

Channel mapping: 1:1, Auto

Downmix to: 5.1 SMPTE

LFE Lowpass: 60 Hz, Off On

Head tracking: Yaw 0°, Pitch 0°, Roll 0°, Manual OSC

Room loudness normalisation: Off On

Room damping: High 48%, Low 100%

Reverb liveliness: High 42%, Low 50%

**VIRTUOSO**  
Powered by **ASPEN™** View Settings Matrix HPC EQ **APL** APPLIED PSYCHOACOUSTICS LAB

Input

			1	2	3	4	5	6	7	8	9	10	11	12
Loudspeaker	L	S M	0.0										-3.0	
	R	S M		0.0										-3.0
	C	S M			0.0									
	LFE	S M				0.0								
	Ls	S M					-6.0		-6.0					-3.0
	Rs	S M						-6.0		-6.0				-3.0

### 3.5 HPC EQ

The HPC EQ tab provides a 10-band parametric equaliser for customising the HPC EQ profile loaded. When no HPC EQ profile is selected (None), you can still use the parametric equaliser for adjusting the tonal balance of the output signals.

The current version (2.0.0) does not have an interactive EQ GUI; frequency, gain and Q need to be controlled using the sliders or by inputting a value into the number box manually. A future version will include an interactive EQ GUI as well as a custom profile saving function.



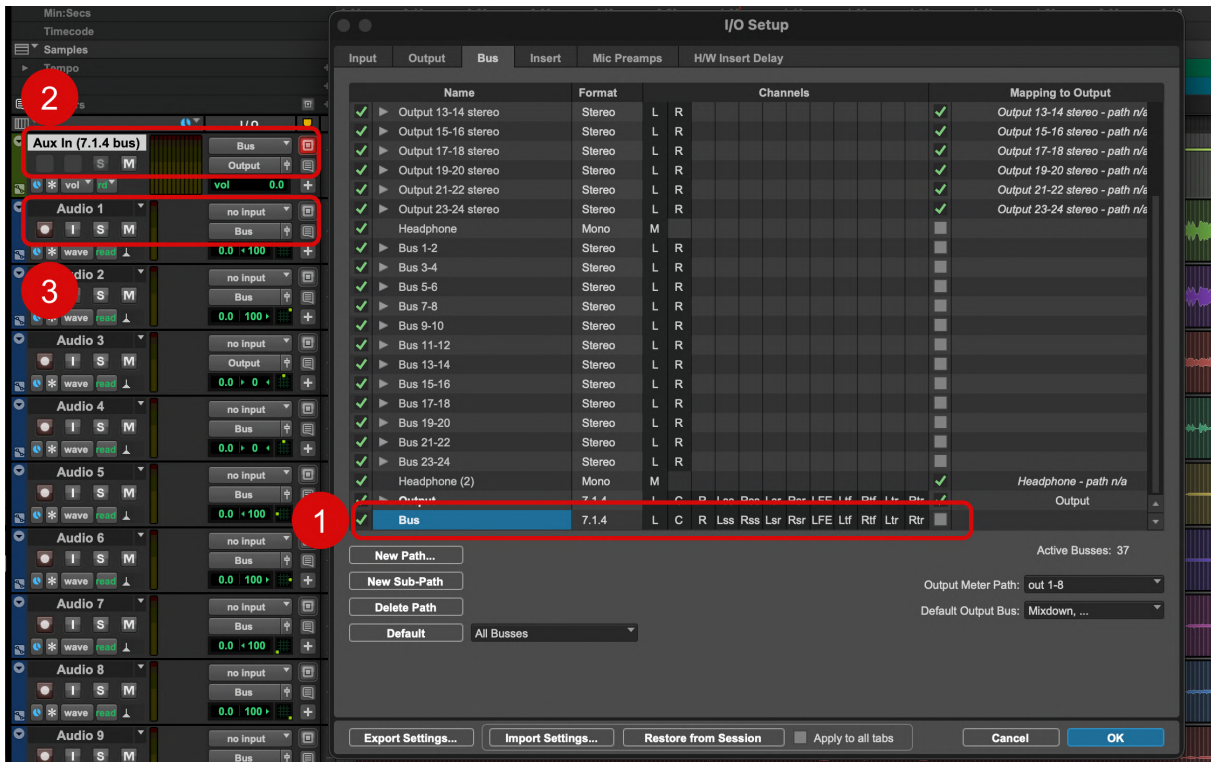
## 4 DAW SETUP

To use Virtuoso for monitoring a **Stereo** mix, all you need to do is simply to **insert Virtuoso in the Master track**. For multichannel or Dolby Atmos mix, however, different DAWs use their own workflows. This section presents quick set-up instructions and examples for popular DAWs used for 3D audio production: Pro Tools, Reaper, Logic Pro X, Nuendo, Pyramix and Studio One.

### 4.1 Pro Tools

Recent versions of Pro Tools offer increased track widths for multichannel audio work (up to 9.1.6 and 7th order Ambisonics for Pro Tools Ultimate and 7.1.4 and 3rd order Ambisonics for Pro Tools Studio). Pro Tools 2024.3 also support integrated Dolby Atmos Renderer and live re-render for monitoring. Virtuoso can be inserted into a multichannel Aux track for binaurally monitoring either source tracks routed directly into the Aux track or Channel Bed and Object signals that are rendered using the integrated Dolby Atmos Renderer.

#### 4.1.1 Basic setup

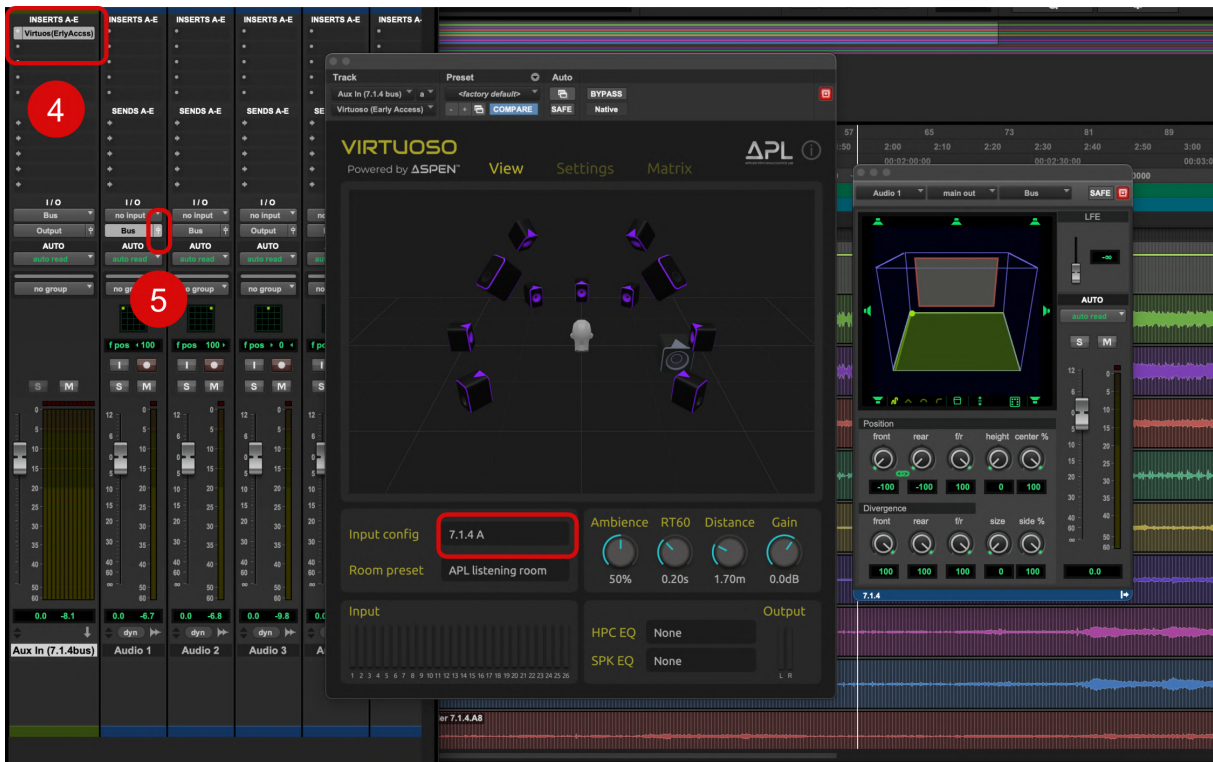


Below is the procedure for setting up a 7.1.4 session with Virtuoso (direct routing into a multichannel Aux track)

1. In Setup - I/O, add a new 7.1.4 Bus path.
2. Create a new 7.1.4 **Aux Input** track, and assign the input to Bus (7.1.4).
3. Create individual Audio tracks, and assign the output of each to Bus (7.1.4).
4. Insert Virtuoso in the Aux Input track (make sure you select the N/Stereo option, e.g. 7.1.4/Stereo), and set the input config to Dolby Atmos 7.1.4.
5. Open the 3D Panner on each Audio track and locate the source to a desired position.

**Note:** Virtuoso is supposed to show only the N/Stereo option when it's inserted in an Aux track with a track width of N channels (e.g. 7.1.4/Stereo).

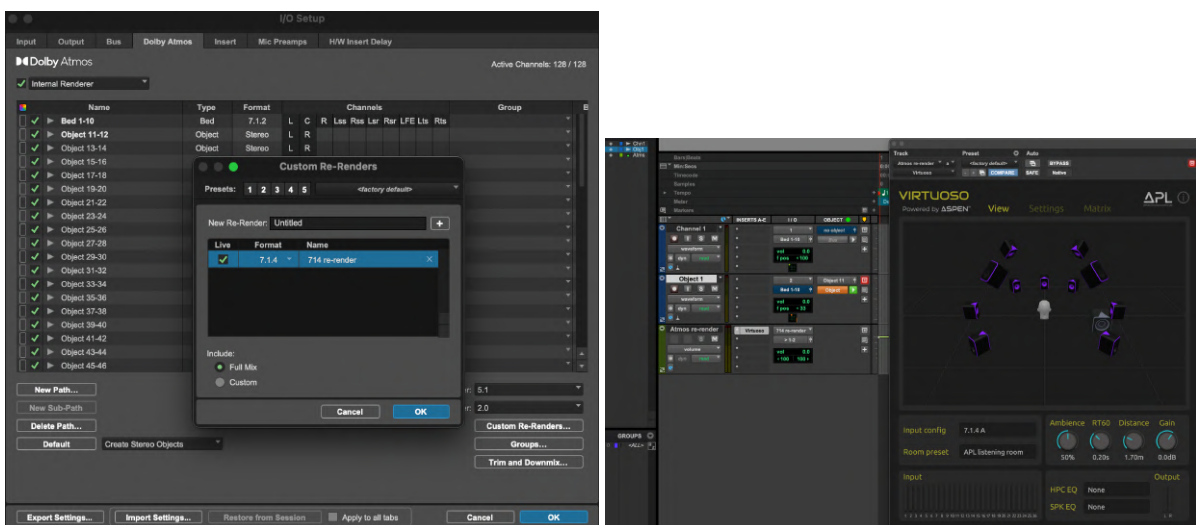




#### 4.1.2 Monitoring live re-render from Dolby Atmos Renderer

Below is the procedure for setting up a live re-render of Dolby Atmos Renderer and set up a multi-channel Aux track.

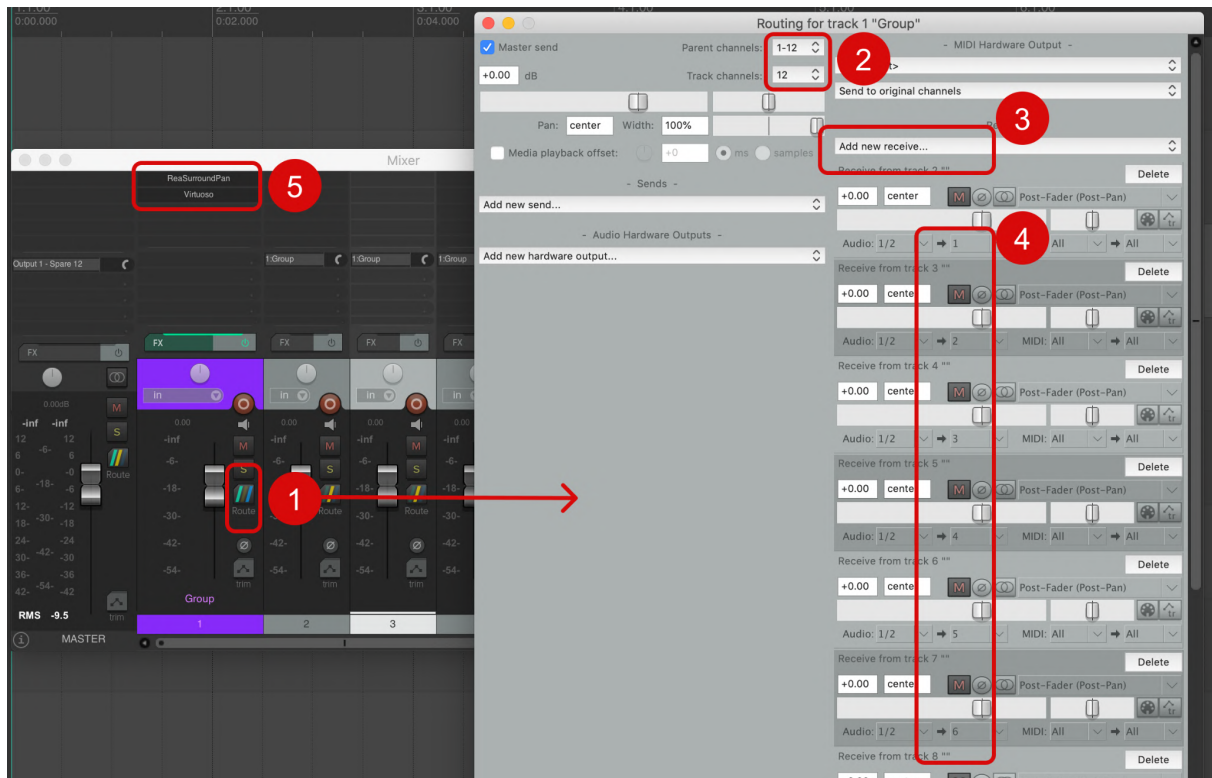
1. In Setup - I/O - Dolby Atmos tab, select and click Internal Renderer.
2. Click the Custom Re-Renders button and create a new re-render (e.g. 7.1.4).
3. On the multichannel Aux track where Virtuoso is inserted, Set the input to Re-Renders and select the re-renderer you created.
4. Select the same input configuration as the re-render in Virutoso (e.g. Dolby Atmos 7.1.4 A).



## 4.2 Reaper

Reaper offers a flexible routing functionality, supporting up to 64 input channels for a group (bus) track, which made it popular for multichannel audio work.

### 4.2.1 Basic setup

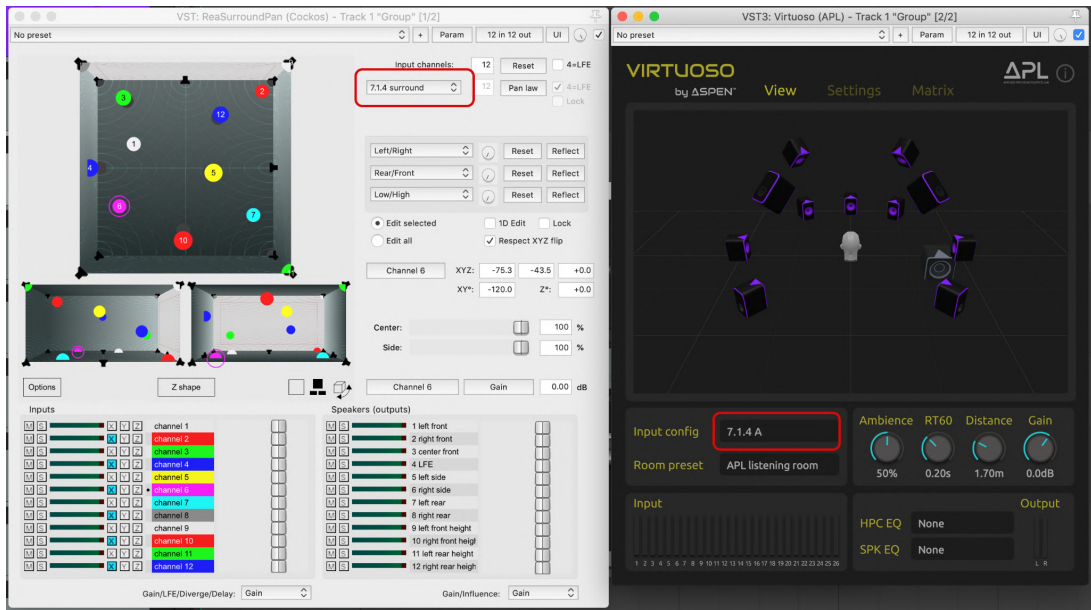


Below is the procedure for setting up a multichannel group track where Virtuoso and a panner plugin need to be inserted.

1. Create a new track to be used as a Group (or bus) and click the “Route” button.
2. Set the Track Channels to the number of your source tracks (Reaper supports up to 64 channels).
3. Add new receive tracks. For convenience, you can use “Add receives from all tracks”. Make sure the source tracks have the Master send turned **off** in Routing, so that only the binauralised sounds in the Group track are heard.
4. Each of the received tracks should be assigned to each input number, so that they can be routed to each object or channel in ReaSurroundPan, or directly in Virtuoso, respectively.
5. Insert Virtuoso and if needed, a panner plugin too on the Group track. If the source tracks are your stereo or multichannel master stems, you would only need Virtuoso to directly binauralise them. But if your individual source tracks are so-called “objects” that need to be panned in surround or 3D, you can insert Reaper’s stock plugin called “ReaSurroundPan” or any other third-party 3D panner before Virtuoso. See the next section for example.

### 4.2.2 Using Virtuoso with a multichannel panner plugin

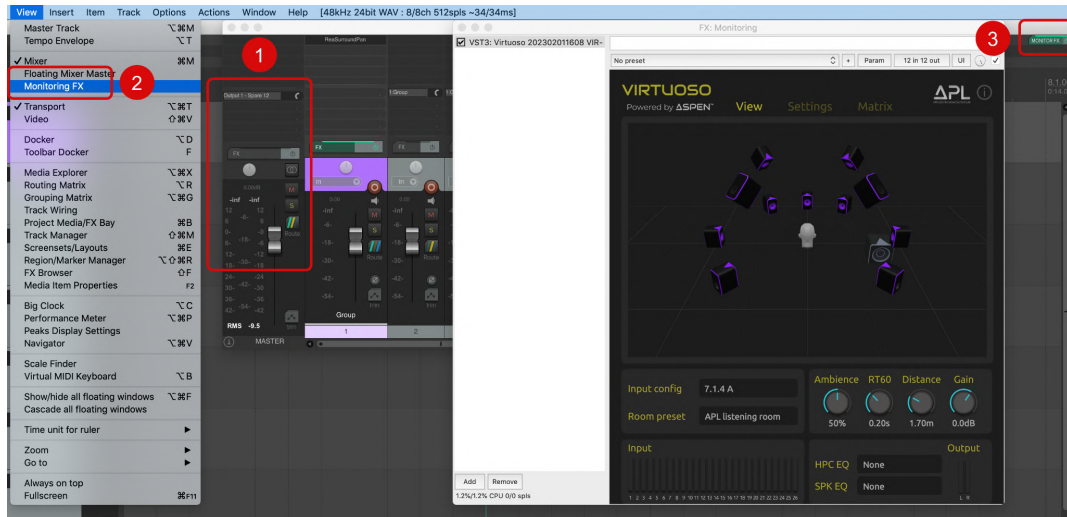
On ReaSurroundPan, or any other 3D panner which is inserted before Virtuoso, make sure the Input Channels option (e.g. 7.1.4 surround in the example below) matches the Input Config option on Virtuoso (e.g. Dolby Atmos 7.1.4). If the channel order provided by Reaper does not match to the standard channel order used by Virtuoso, you can use the Matrix tab to re-route the input channels and loudspeakers.



### 4.2.3 Use Virtuoso in Monitor FX

Another useful way to use Virtuoso is to insert it directly into Monitor FX instead of the group track. This allows you to monitor the master output from any session currently open in Reaper through Virtuoso globally; you don't need to insert Virtuoso on every session, but just in the MonitorFX path.

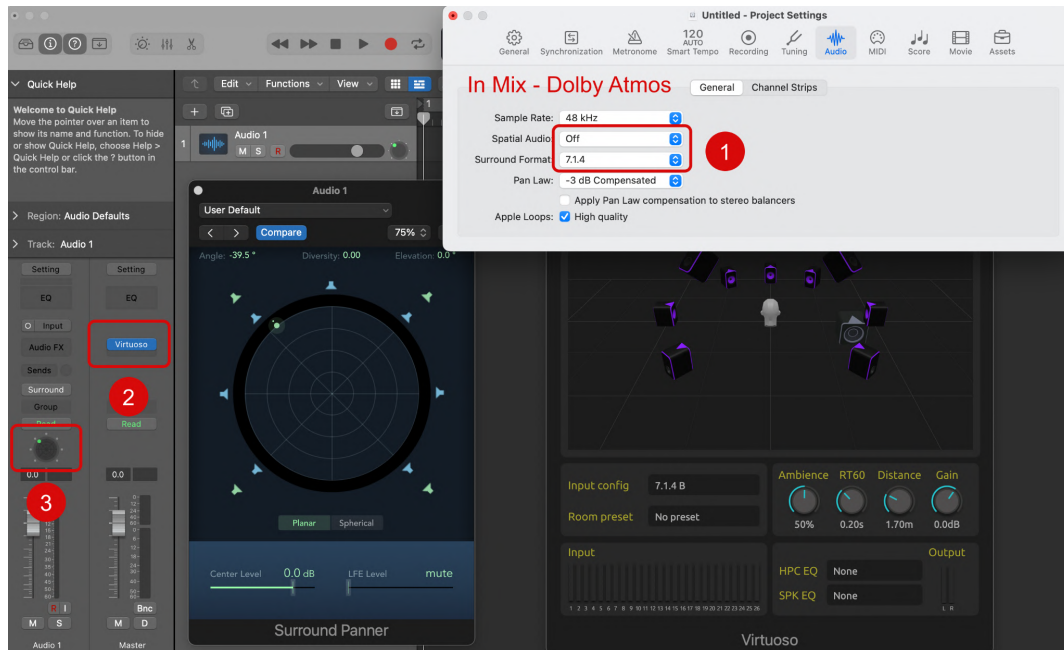
1. First, in the Routing section of the Master track, set Track Channels to the same number (e.g. 12) as the total number of channels used in the Input Config on Virtuoso (e.g. 7.1.4), and set the Multichannel Source to the maximum value available (e.g. 1-12).
2. Select Monitoring FX in the View tab on the Reaper menu bar, and insert Virtuoso there.
3. Turn on the MonitorFX button on the top right-hand corner of Reaper.



## 4.3 Logic Pro X

Logic Pro X offers Dolby Atmos renderer and object panner plugins as well as generic surround panning and multichannel outputs up to 7.1.4. Virtuoso can be used to binaurally monitor the mix output signals more accurately than the stock binaural options.

### 4.3.1 Basic setup



First, set Audio Output to Surround when creating a new multichannel session. For a generic surround (non-Atmos) mix, follow the procedure below.

1. Navigate to Mix - Dolby Atmos on the top menu bar, and set Spatial Audio to **Off**, and select a Surround Format you want (e.g. 7.1.4).
2. Insert Virtuoso on the Master track and select the same Input Config as the Surround Format (e.g. Dolby Atmos 7.1.4).

**Note:** Logic Pro X uses a different channel order to the standard SMPTE standard (e.g. Dolby Atmos) for 5.1.4 and 7.1.4. Previous versions of Virtuoso included the dedicated Input Configs 5.1.4 Logic Pro and 7.1.4 Logic Pro. However, v1.2.1 includes the new Channel Mapping feature to address this issue. Simply select "**Auto**" in **Settings - Channel Mapping**, and the input channels and virtual loudspeakers will be correctly mapped.

3. Open the surround panner on each track.

### 4.3.2 Using Virtuoso with the Dolby Atmos renderer

You can use Virtuoso instead of Dolby or Apple binaural renderer in order to monitor the Atmos mix output more accurately. Use the following procedure.

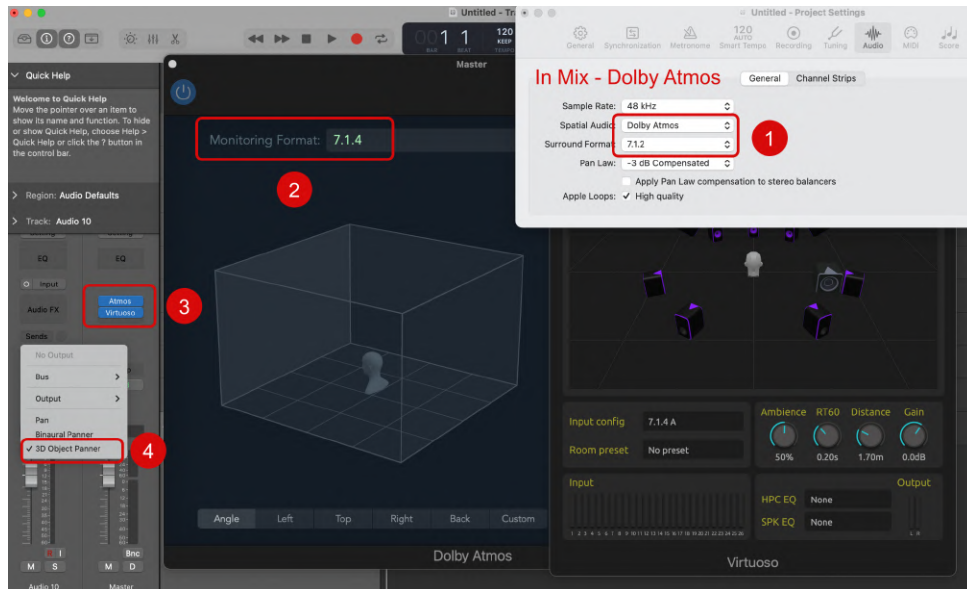
1. Navigate to Mix - Dolby Atmos. Set Spatial Audio to Dolby Atmos. The Surround Format will automatically be set to 7.1.2 by default. This is not to be confused with the Monitoring Format available in the Dolby Atmos Renderer. 7.1.2 is the largest format for what Dolby calls "channel bed".
2. The above step will automatically insert the Atmos renderer plugin in the Master track. Ensure Virtuoso is inserted after the Atmos plugin, and the Monitoring Format in Atmos is set to 7.1.4



or any other desired format, rather than any binaural renderer. This will feed the final Atmos output signals into Virtuoso for monitoring.

3. For any audio tracks that you want to make “objects” for, click “Surround” or hover over the panner and right click, then select “3D Object Panner”.

**Note:** To pan any sources directly to all four height loudspeakers in 7.1.4 (Ltf, Rtf, Ltr and Rtr) or anywhere between them, you need to make your track an object.



## 4.4 Nuendo

Nuendo provides Dolby Atmos renderer and object panning plugins. As in Logic Pro X, you need to insert Virtuoso after the Atmos plugin and ensure the Atmos plugin outputs 7.1.4 or 5.1.4 rather than binaurally rendered signals. However, Nuendo requires a specific configuration for a Dolby Atmos project. Please carefully follow the instructions provided in the link below.

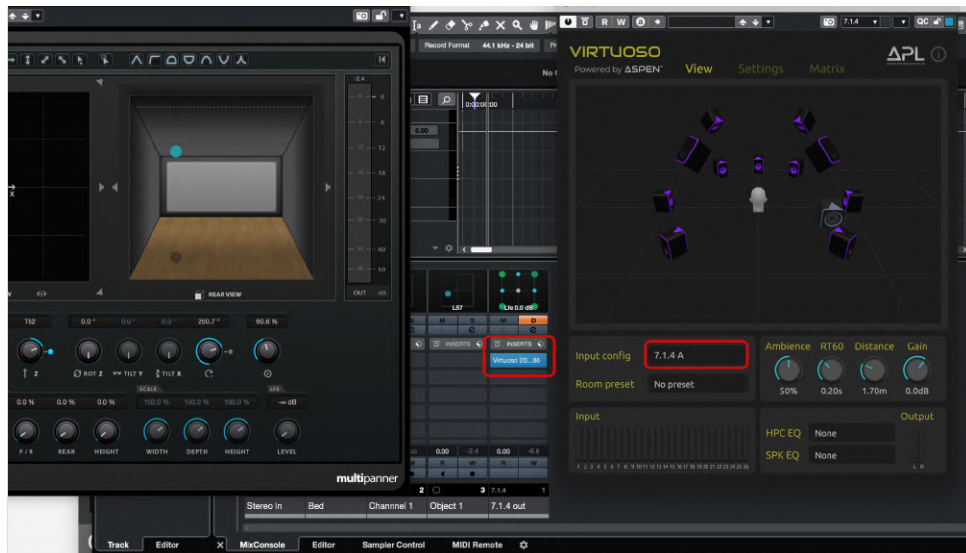
[https://steinberg.help/nuendo/v11/en/cubase\\_nuendo/topics/surround\\_sound/surround\\_sound\\_adm\\_authoring\\_internal\\_renderer\\_setting\\_up\\_t.html](https://steinberg.help/nuendo/v11/en/cubase_nuendo/topics/surround_sound/surround_sound_adm_authoring_internal_renderer_setting_up_t.html)

**Note:** Cubase has a similar workflow to Nuendo: [https://steinberg.help/cubase\\_pro/v12/en/cubase\\_nuendo/topics/surround\\_sound/surround\\_sound\\_dolby\\_atmos\\_setup\\_c.html](https://steinberg.help/cubase_pro/v12/en/cubase_nuendo/topics/surround_sound/surround_sound_dolby_atmos_setup_c.html)

### 4.4.1 Basic setup

Insert Virtuoso on the Atmos master output track. Select 7.1.4 A or 7.1.4 B in Input Config.

**Note:** Nuendo and Cubase use a different channel order to the standard SMPTE standard (e.g. Dolby Atmos) for 7.1.4. (e.g. Nuendo uses channels 5 and 6 for Left/Right “rear” surround, whereas Dolby Atmos standard uses them for Left/Right “side” surround.). Previous versions of Virtuoso included the dedicated Input Configs 7.1.4 Nuendo. However, v1.2.1 includes the new Channel Mapping feature to address this issue. Simply select “Auto” in **Settings - Channel Mapping**, and the input channels and virtual loudspeakers will be correctly mapped.



## 4.5 Pyramix

Pyramix is a popular DAW for classical music recording and editing. It is for Windows operating systems only. Setting up a multichannel project on Pyramix requires you to follow several steps. The manual is available on the link below. [https://www.merging.com/uploads/assets/Installers/KHEPRI\\_X.0.5\\_HotFix4/Pyramix\\_14.0.5\\_HotFix4/Pyramix\\_14\\_User\\_Manual.pdf](https://www.merging.com/uploads/assets/Installers/KHEPRI_X.0.5_HotFix4/Pyramix_14.0.5_HotFix4/Pyramix_14_User_Manual.pdf)

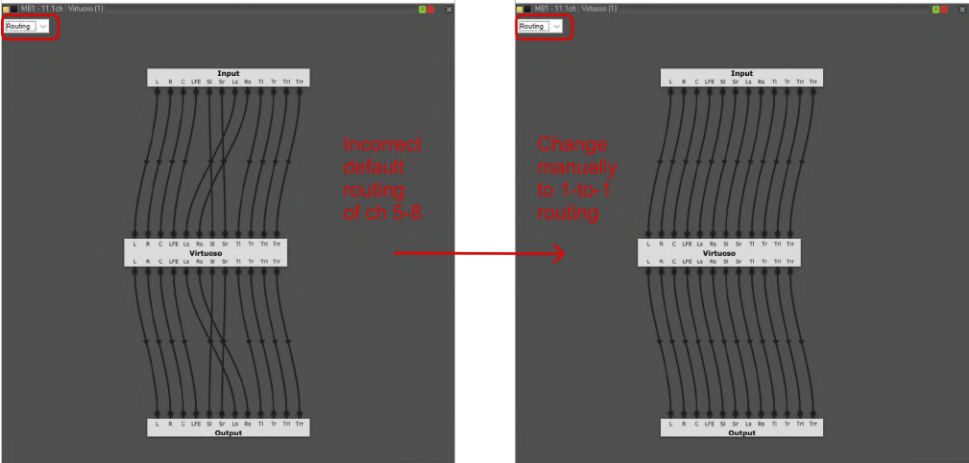
### 4.5.1 Basic setup

Insert Virtuoso on the master bus. Pyramix uses different labelling conventions to Dolby Atmos and some speaker configurations use unconventional channel orders too (e.g. 9.1.6). Previous versions of Virtuoso included the dedicated Input Configs 7.1.4 Pyramix. However, v1.2.1 includes the new Channel Mapping feature to address this issue. Simply select "**Auto**" in **Settings - Channel Mapping**, and the input channels and virtual loudspeakers will be correctly mapped.



**Note:** Pyramix automatically routes channels between inputs/outputs and plugin(s) inserted. This can be seen by selecting **Routing** in the dropdown menu on the top left corner. However, for an unknown reason, the automatic routings Pyramix does for Virtuoso are **incorrect** for some formats such as 7.1.4 and 9.1.6. As can be seen in the screenshot below for instance, channels 5 and 6 of Pyramix's inputs and outputs are routed to channels 7 and 8 of Virtuoso. This is because somehow

Pyramix misinterprets the channel order of Virtuoso. Therefore, the routing must be corrected by manually selecting the connection arrows and moving them so that Pyramix and Virtuoso simply have a **1:1 routing** as shown in the screenshot. The channel orders for Dolby Atmos formats in Virtuoso are correct, and they follow the Dolby's standard, which is also in line with the channel in Pyramix.

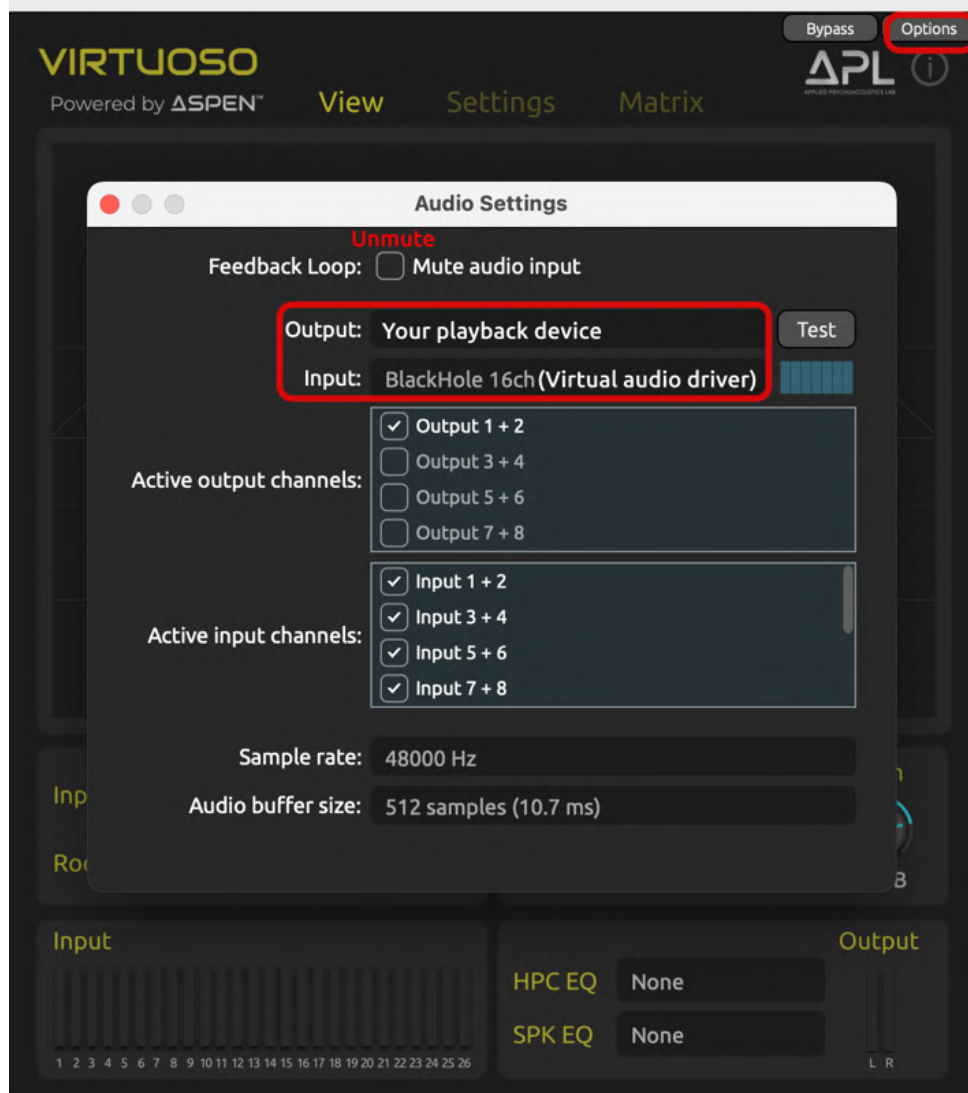




## 5 STANDALONE APP SETUP

The Virtuoso standalone app is useful for listening to computer audio or DAW multichannel output signals in binaural outside the DAW. This requires a virtual audio driver, such as Black Hole Audio (free download) <https://existential.audio/blackhole/> which allows you to route audio from the computer or a DAW into Virtuoso. Follow the procedure below.

1. When you open the app first time, navigate to Options – Audio Settings, and **unmute** the audio input. Select a virtual audio driver such as BlackHole 16ch as Input. Output should be your playback device. You can feed audio from your computer audio or another renderer (e.g. Dolby Atmos Production Suite) into Virtuoso via the virtual audio driver.



2. On your Mac, navigate to System Preferences - Sound and select your Virtual audio driver. You can do the same in Audio Midi Setup.

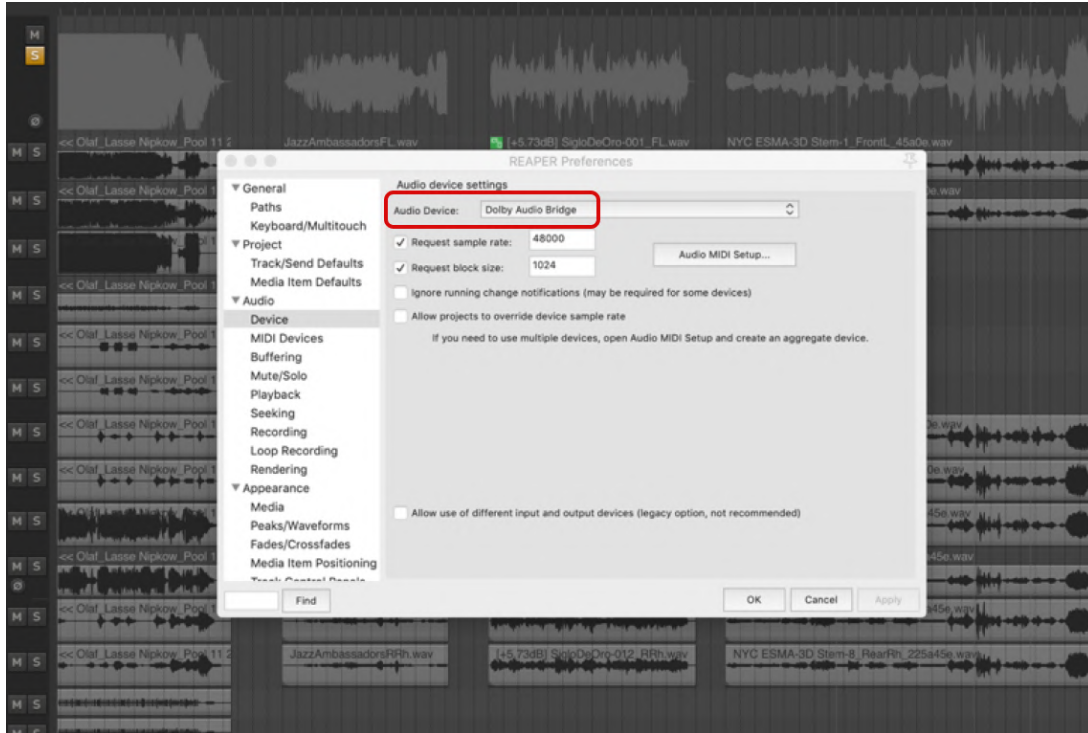
The subsections below introduce two useful example scenarios of the standalone app on MacOS: 1. Binaural monitoring of 7.1.4 outputs from Dolby Atmos Production Suite (DAPS) and 2. Listening to Apple Music's multichannel streaming of Dolby Atmos 7.1.4 in Virtuoso binaural

### 5.1 Monitoring of 7.1.4 outputs from Dolby Atmos Production Suite (DAPS)

Although Dolby Atmos provides its own binaural renderer, Virtuoso could offer a more accurate binaural translation of loudspeaker listening experience and more customisable virtual room acoustics. This section shows the workflow for using the Virtuoso standalone app in conjunction with

DAPS. In this example, we will use the **Reaper** DAW. But the basic workflow is identical in the **Pro Tools** or other DAW environment. **Pre-requisites:** DAPS, Dolby Audio Bridge app and Dolby Music Panner plugin <https://professional.dolby.com/product/dolby-atmos-content-creation/dolby-atmos-renderer/>

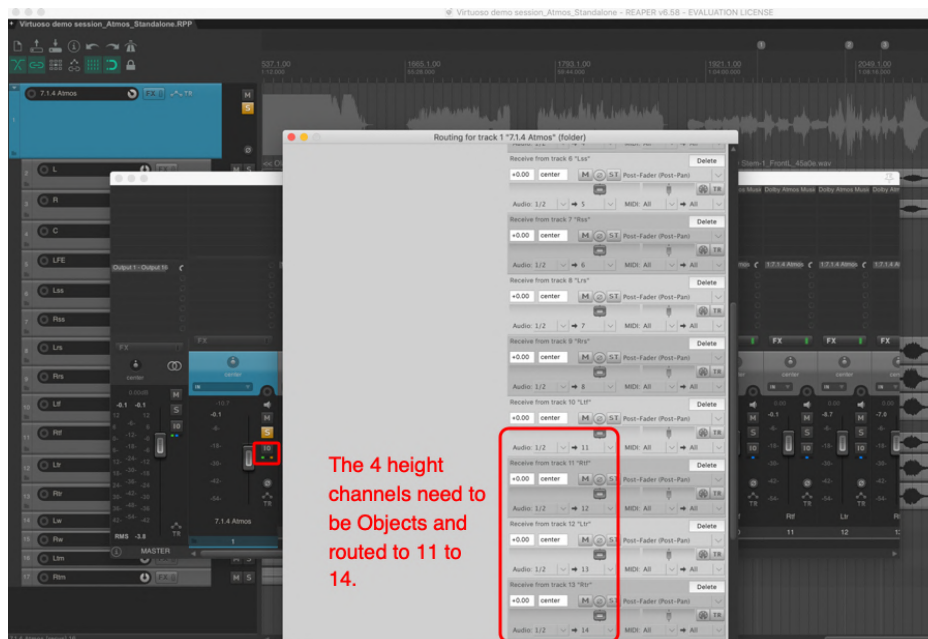
1. In Reaper, go to Preferences - Audio device settings, and set the audio device to Dolby Audio Bridge.



2. Create a bus track that receives 12 track channels (for 7.1.4). The individual source tracks should have the master output unselected. The 7.1.4 bus track should route each source track to a specific output. If these are used as the channel bed for 7.1.2, each source track should be routed to 1 to 10.

**Note:** Dolby Atmos 7.1.2 channel bed automatically assigns channel 9 to outputs 9 and 11, and channel 10 to outputs 10 and 12 in the 7.1.4 speaker configuration, i.e. channels 9 and 10 create phantom side left and right height between Top front and Top rear speakers. To avoid this, it is recommended to use “Objects” for height speaker signals, e.g. if you have discrete multichannel recordings made for 7.1.4, the four height channel signals need to become Objects for them to be discretely panned to the four height speakers. Dolby Atmos uses Objects from channel 11 onwards. Therefore, the four height signals need to be routed to 11, 12, 13 and 14, as shown below.

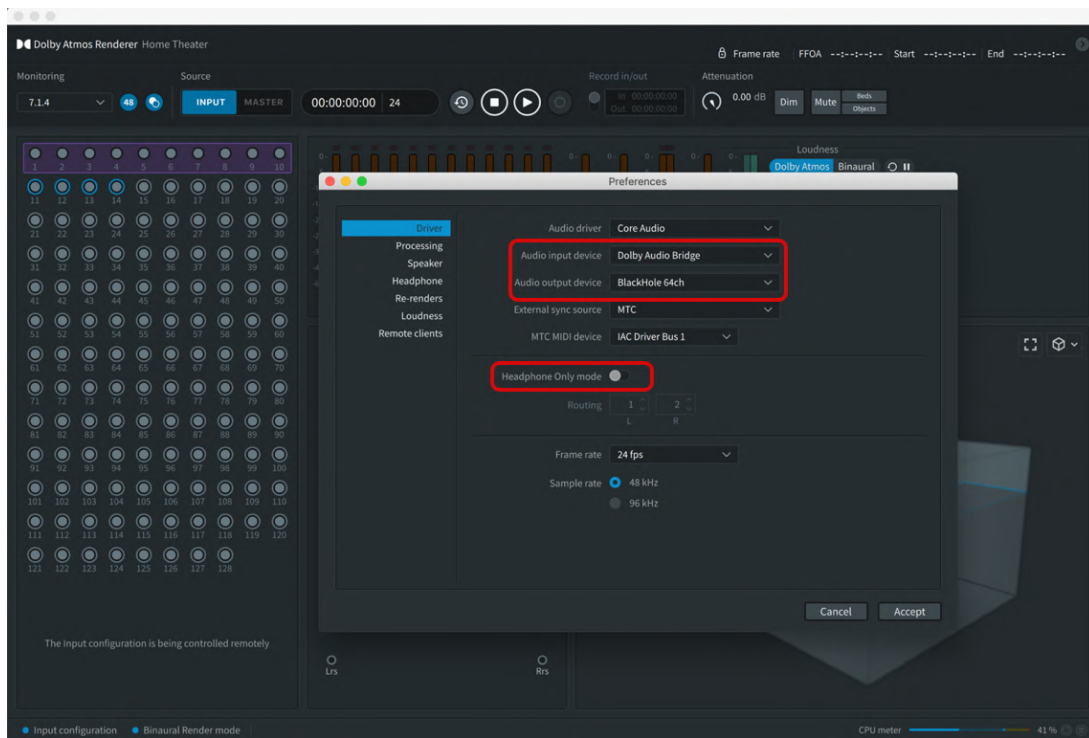
In general, it would be best to keep the channel bed to the horizontal speakers only, and use Objects for any elevated sources.



3. The height channel signals need to be panned to the desired positions using the Dolby Music Panner plugin. The panner has the option to control two objects in stereo. But for each of the 4 height channels in this example, we use only one of the objects and route it to the corresponding object number 11...14. e.g. Top front left = 11, panned to the top left corner (z = 100). Top front right = 12, panned to the top right corner (z = 100), etc.



4. In DAPS, go to Preferences - Driver, and set Audio Input Device to Dolby Audio Bridge and Audio Output Device to your virtual audio driver (e.g. Blackhole). Select 7.1.4 in Monitoring. And make sure Headphone Only mode is turned off.

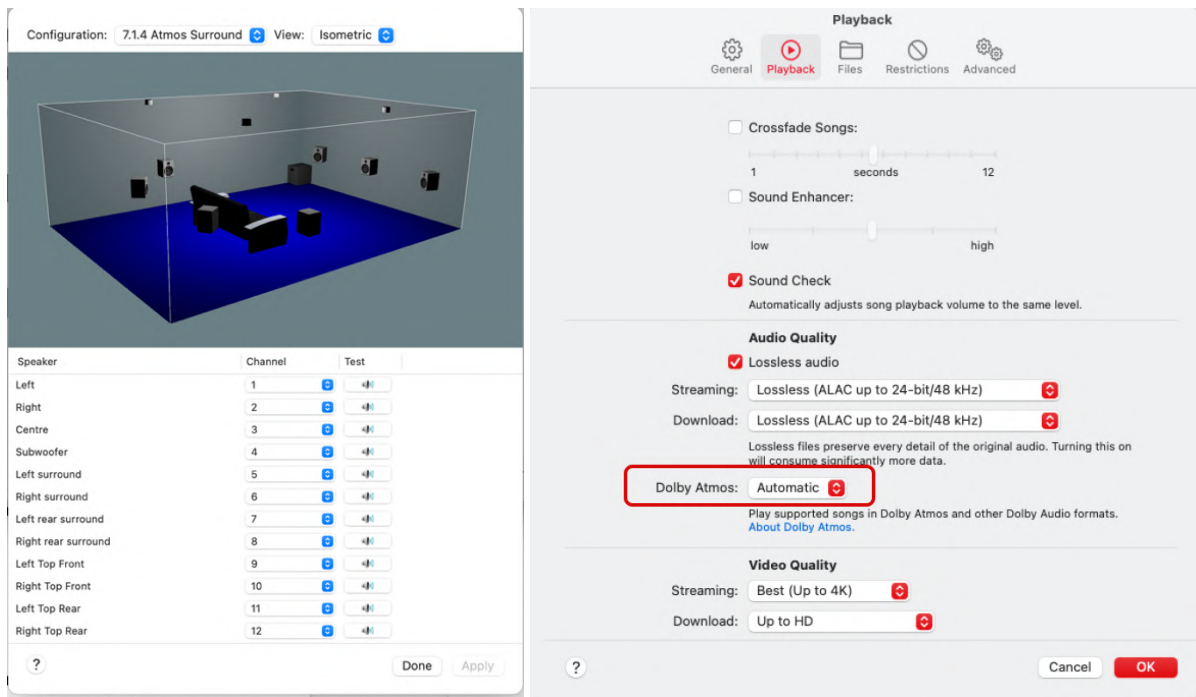


5. In Virtuoso, the Input needs to be the same virtual driver (BlackHole) used as Output in Dolby Atmos Renderer.

## 5.2 Listening to Apple Music Dolby Atmos 7.1.4 streaming in Virtuoso

If you use MacOS version Monterey 12.5 or higher, you can listen to Dolby Atmos music from Apple Music using Virtuoso.

1. In Audio Midi Setup, select your virtual audio driver (Blackhole in this example) as the output device. Right click over the driver – Configure speakers will show the screen below. Select 7.1.4 Dolby Atmos Atmos Surround.
2. In the Apple Music desktop app, go to Preferences – Playback, and select Automatic in the Dolby Atmos setting. This will feed 7.1.4 audio stream into the virtual audio driver.
3. In Virtuoso, go to Options and select the same virtual audio driver as the input device. Now you can listen to the multichannel Atmos music in a more accurate and spacious binaural using Virtuoso.



## 6 LOUDSPEAKER LAYOUTS

This section presents the loudspeaker layout and channel order used for each Input Config. Currently, there is an inconsistency in the labelling of individual channels for different reproduction formats; e.g., different formats often use different labels for the same loudspeaker positions, which often causes confusion. Moreover, some DAWs use different channel orders for the same reproduction formats. In the tables presented from the following pages, you can check the labels and order of the input channels and the azimuth and elevation angles (degrees) of each loudspeaker used.

**Note:** The angular orientation used for the loudspeaker layout is **anticlockwise**, e.g.  $30^\circ$  for front left  $-30^\circ$  for front right.

# MONO, STEREO AND ITU-R SURROUND

## Mono

Label	Azimuth	Elevation
C	0	0

## Stereo

Label	Azimuth	Elevation
L	30	0
R	-30	0

## Stereo Narrow

Label	Azimuth	Elevation
L	15	0
R	-15	0

## Stereo Wide

Label	Azimuth	Elevation
L	45	0
R	-45	0

## ITU-R 5.1 SMPTE

Label	Azimuth	Elevation
L	30.0	0.0
R	-30.0	0.0
C	0.0	0.0
LFE	-45	-30
Ls	110.0	0.0
Rs	-110.0	0.0

## ITU-R 5.1 Film

Label	Azimuth	Elevation
L	30.0	0.0
C	0.0	0.0
R	-30.0	0.0
Ls	110.0	0.0
Rs	-110.0	0.0
LFE	-45	-30

## ITU-R 7.1 A SMPTE

Label	Azimuth	Elevation
L	30.0	0.0
R	-30.0	0.0
C	0.0	0.0
LFE	-45	-30
Lss	110.0	0.0
Rss	-110.0	0.0
Lrs	150.0	0.0
Rrs	-150.0	0.0

## ITU-R 7.1 A Film

Label	Azimuth	Elevation
L	30.0	0.0
C	0.0	0.0
R	-30.0	0.0
Lss	110.0	0.0
Rss	-110.0	0.0
Lrs	150.0	0.0
Rrs	-150.0	0.0
LFE	-45	-30

## ITU-R 7.1 B SMPTE

Label	Azimuth	Elevation
L	30.0	0.0
R	-30.0	0.0
C	0.0	0.0
LFE	-45	-30
Lss	90.0	0.0
Rss	-90.0	0.0
Lrs	135.0	0.0
Rrs	-135.0	0.0

## ITU-R 7.1 B Film

Label	Azimuth	Elevation
L	30.0	0.0
C	0.0	0.0
R	-30.0	0.0
Lss	90.0	0.0
Rss	-90.0	0.0
Lrs	135.0	0.0
Rrs	-135.0	0.0
LFE	-45	-30

# ISO IEC MPEG-H

## ISO IEC MPEG-H 5.1+2H

Label	Azimuth	Elevation
L030	30.0	0.0
R030	-30.0	0.0
C000	0.0	0.0
LFE	-45	-30
L110	110.0	0.0
R110	-110.0	0.0
UL030	30.0	37.0
UR030	-30.0	37.0

## ISO IEC MPEG-H 7.1+2H

Label	Azimuth	Elevation
L030	30.0	0.0
R030	-30.0	0.0
C000	0.0	0.0
LFE	-45	-30
L135	135.0	0.0
R135	-135.0	0.0
L090	90.0	0.0
R090	-90.0	0.0
UL090	90.0	37.0
UR090	-90.0	37.0

## ISO IEC MPEG-H 5.1+4H

Label	Azimuth	Elevation
L030	30.0	0.0
R030	-30.0	0.0
C000	0.0	0.0
LFE	-45	-30
L110	110.0	0.0
R110	-110.0	0.0
UL030	30.0	37.0
UR030	-30.0	37.0
UL110	110.0	37.0
UR110	-110.0	37.0

## ISO IEC MPEG-H 7.1+4H

Label	Azimuth	Elevation
L030	30.0	0.0
R030	-30.0	0.0
C000	0.0	0.0
LFE	-45	-30
L135	135.0	0.0
R135	-135.0	0.0
L090	90.0	0.0
R090	-90.0	0.0
UL030	30.0	37.0
UR030	-30.0	37.0
UL135	135.0	37.0
UR135	-135.0	37.0

## ISO IEC MPEG-H 5.1+6H

Label	Azimuth	Elevation
L030	30.0	0.0
R030	-30.0	0.0
C000	0.0	0.0
LFE	-45	-30
L110	110.0	0.0
R110	-110.0	0.0
UL030	30.0	37.0
UR030	-30.0	37.0
UC000	0.0	37.0
UL110	110.0	37.0
UR110	-110.0	37.0
TC000	0.0	90.0



# DOLBY ATMOS

## Dolby Atmos 5.1.2

Label	Azimuth	Elevation
L	30.0	0.0
R	-30.0	0.0
C	0.0	0.0
LFE	-45	-30
Ls	110.0	0.0
Rs	-110.0	0.0
Ltf	90.0	45.0
Rtf	-90.0	45.0

## Dolby Atmos 7.1.2 B

Label	Azimuth	Elevation
L	30.0	0.0
R	-30.0	0.0
C	0.0	0.0
LFE	-45	-30
Lss	110.0	0.0
Rss	-110.0	0.0
Lrs	150.0	0.0
Rrs	-150.0	0.0
Ltm	90.0	45.0
Rtm	-90.0	45.0

## Dolby Atmos 5.1.4

Label	Azimuth	Elevation
L	30.0	0.0
R	-30.0	0.0
C	0.0	0.0
LFE	-45	-30
Ls	110.0	0.0
Rs	-110.0	0.0
Ltf	45.0	45.0
Rtf	-45.0	45.0
Ltr	135.0	45.0
Rtr	-135.0	45.0

## Dolby Atmos 7.1.4 A

Label	Azimuth	Elevation
L	30.0	0.0
R	-30.0	0.0
C	0.0	0.0
LFE	-45	-30
Lss	90.0	0.0
Rss	-90.0	0.0
Lrs	135.0	0.0
Rrs	-135.0	0.0
Ltf	45.0	45.0
Rtf	-45.0	45.0
Ltr	135.0	45.0
Rtr	-135.0	45.0

## Dolby Atmos 7.1.2 A

Label	Azimuth	Elevation
L	30.0	0.0
R	-30.0	0.0
C	0.0	0.0
LFE	-45	-30
Lss	90.0	0.0
Rss	-90.0	0.0
Lrs	135.0	0.0
Rrs	-135.0	0.0
Ltm	90.0	45.0
Rtm	-90.0	45.0

## Dolby Atmos 7.1.4 B

Label	Azimuth	Elevation
L	30.0	0.0
R	-30.0	0.0
C	0.0	0.0
LFE	-45	-30
Lss	110.0	0.0
Rss	-110.0	0.0
Lrs	150.0	0.0
Rrs	-150.0	0.0
Ltf	45.0	45.0
Rtf	-45.0	45.0
Ltr	135.0	45.0
Rtr	-135.0	45.0

### Dolby Atmos 9.1.6 A

Label	Azimuth	Elevation
L	30.0	0.0
R	-30.0	0.0
C	0.0	0.0
LFE	-45	-30
Lws	60.0	0.0
Rws	-60.0	0.0
Lss	90.0	0.0
Rss	-90.0	0.0
Lrs	135.0	0.0
Rrs	-135.0	0.0
Ltf	45.0	45.0
Rtf	-45.0	45.0
Ltm	90.0	45.0
Rtm	-90.0	45.0
Ltr	135.0	45.0
Rtr	-135.0	45.0

### Dolby Atmos 9.1.6 B

Label	Azimuth	Elevation
L	30.0	0.0
R	-30.0	0.0
C	0.0	0.0
LFE	-45	-30
Lws	60.0	0.0
Rws	-60.0	0.0
Lss	110.0	0.0
Rss	-110.0	0.0
Lrs	150.0	0.0
Rrs	-150.0	0.0
Ltf	45.0	45.0
Rtf	-45.0	45.0
Ltm	90.0	45.0
Rtm	-90.0	45.0
Ltr	135.0	45.0
Rtr	-135.0	45.0

## Auro-3D

### Auro-3D 9.1

Label	Azimuth	Elevation
L	30.0	0.0
R	-30.0	0.0
C	0.0	0.0
LFE	-45	-30
Ls	110.0	0.0
Rs	-110.0	0.0
HL	30.0	30.0
HR	-30.0	30.0
HLs	110.0	30.0
HRs	-110.0	30.0

### Auro-3D 13.1

Label	Azimuth	Elevation
L	30.0	0.0
R	-30.0	0.0
C	0.0	0.0
LFE	-45	-30
Ls	90.0	0.0
Rs	-90.0	0.0
Lb	135.0	0.0
Rb	-135.0	0.0
HL	30.0	30.0
HR	-30.0	30.0
HC	0.0	30.0
T	0.0	90.0
HLs	110.0	30.0
HRs	-110.0	30.0

### Auro-3D 11.1

Label	Azimuth	Elevation
L	30.0	0.0
R	-30.0	0.0
C	0.0	0.0
LFE	-45	-30
Ls	110.0	0.0
Rs	-110.0	0.0
HL	30.0	30.0
HR	-30.0	30.0
HC	0.0	30.0
T	0.0	90.0
HLs	110.0	30.0
HRs	-110.0	30.0

## NHK 22.2

### NHK 22.2 A

Label	Azimuth	Elevation
FL	60.0	0.0
FR	-60.0	0.0
FC	0.0	0.0
LFE1	45	-30
BL	135.0	0.0
BR	-135.0	0.0
FLc	30.0	0.0
FRc	-30.0	0.0
BC	180.0	0.0
LFE2	-45	-30
SiL	90.0	0.0
SiR	-90.0	0.0
TpFL	45.0	45.0
TpFR	-45.0	45.0
TpFC	0.0	45.0
TpC	0.0	90.0
TpBL	135.0	45.0
TpBR	-135.0	45.0
TpSiL	90.0	45.0
TpSiR	-90.0	45.0
TpBC	180.0	45.0
BtFC	0.0	-30.0
BtFL	45.0	-30.0
BtFR	-45.0	-30.0

### NHK 22.2 B

Label	Azimuth	Elevation
FL	60.0	0.0
FR	-60.0	0.0
FC	0.0	0.0
LFE1	45	-30
BL	135.0	0.0
BR	-135.0	0.0
FLc	30.0	0.0
FRc	-30.0	0.0
BC	180.0	0.0
LFE2	-45	-30
SiL	90.0	0.0
SiR	-90.0	0.0
TpFL	45.0	30.0
TpFR	-45.0	30.0
TpFC	0.0	30.0
TpC	0.0	90.0
TpBL	135.0	30.0
TpBR	-135.0	30.0
TpSiL	90.0	30.0
TpSiR	-90.0	30.0
TpBC	180.0	30.0
BtFC	0.0	-30.0
BtFL	45.0	-30.0
BtFR	-45.0	-30.0

# REGULAR ARRAYS

## Regular array Quad

Label	Azimuth	Elevation
1	45	0
2	135	0
3	-135	0
4	-45	0

## Regular array Octagonal A

Label	Azimuth	Elevation
1	22.5	0
2	67.5	0
3	112.5	0
4	157.5	0
5	-157.5	0
6	-112.5	0
7	-67.5	0
8	-22.5	0

## Regular array Cross

Label	Azimuth	Elevation
1	0	0
2	90	0
3	180	0
4	-90	0

## Regular array Octagonal B

Label	Azimuth	Elevation
1	0	0
2	45	0
3	90	0
4	135	0
5	180	0
6	-135	0
7	-90	0
8	-45	0

## Regular array Hexagonal A

Label	Azimuth	Elevation
1	30	0
2	90	0
3	150	0
4	-150	0
5	-90	0
6	-30	0

## Regular array Tetrahedron

Label	Azimuth	Elevation
1	0	35.3
2	90	-35.3
3	180	35.3
4	270	-35.3

## Regular array Hexagonal B

Label	Azimuth	Elevation
1	0	0
2	60	0
3	120	0
4	180	0
5	-120	0
6	-60	0

## Regular array Cube

Label	Azimuth	Elevation
1	45	35.3
2	45	-35.3
3	135	35.3
4	135	-35.3
5	-135	35.3
6	-135	-35.3
7	-45	35.3
8	-45	-35.3

### Regular array Icosahedron

Label	Azimuth	Elevation
1	36	-25
2	108	-25
3	180	-25
4	-108	-25
5	-36	-25
6	72	25
7	144	25
8	-144	25
9	-72	25
10	0	25
11	0	90
12	0	-90

### Regular array 26p Lebedev

Label	Azimuth	Elevation
1	0	0
2	180	0
3	90	0
4	-90	0
5	0	90
6	0	-90
7	90	45
8	90	-45
9	-90	45
10	-90	-45
11	0	45
12	0	-45
13	180	45
14	180	-45
15	45	0
16	-45	0
17	135	0
18	-135	0
19	45	35.3
20	45	-35.3
21	-45	35.3
22	-45	-35.3
23	135	35.3
24	135	-35.3
25	-135	35.3
26	-135	-35.3

### Regular array 2p T-design

Label	Azimuth	Elevation
1	0	0
2	180	0

### Regular array 4p T-design

Label	Azimuth	Elevation
1	45	35.3
2	-45	-35.3
3	135	-35.3
4	-135	35.3

### Regular array 6p T-design

Label	Azimuth	Elevation
1	0	0
2	180	0
3	90	0
4	-90	0
5	0	90
6	0	-90

### Regular array 12p T-design

Label	Azimuth	Elevation
1	0	-31.7
2	-58.3	0
3	-90	58.3
4	0	31.7
5	-121.7	0
6	90	-58.3
7	180	-31.7
8	121.7	0
9	90	58.3
10	180	31.7
11	58.3	0
12	-90	-58.3

## Regular array 24p T-design

Label	Azimuth	Elevation
1	26	15.5
2	-26	-15.5
3	17.1	-25
4	-17.1	25
5	154	-15.5
6	-154	15.5
7	162.9	25
8	-162.9	-25
9	72.9	25
10	107.1	-25
11	116	15.5
12	64	-15.5
13	-107.1	25
14	-72.9	-25
15	-64	15.5
16	-116	-15.5
17	32.3	60
18	-147.8	60
19	-57.8	60
20	122.3	60
21	-32.3	-60
22	147.8	-60
23	57.8	-60
24	-122.3	-60



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## 8 CONTACT

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