Zirkonium MK III User Guide (ver 3.1)

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1. Introduction

1.1 Overview

Zirkonium is a set of MacOSX software tools to aid the composition of spatial music; the software enables composers to design multiple spatial trajectories with an intuitive GUI and arrange them in time. According to the provided trajectory information, the actual audio signals can then be rendered in real-time for virtually any type of 2D or 3D loudspeaker system.

The Software was originally developed for the ZKM Klangdom (Sound Dome), a 3D surround audio system, consisting of 47 loudspeakers [Figure:1.1], but it is also utilized for any 2D and 3D loudspeaker systems.

For developing the latest version of Zirkonium, we focused on improving the aspects of usability, visualisation, efficiency, and compatibility. Consequently, the software structure and the GUI were entirely reassessed and redesigned. Furthermore, a number of functionalities, such as parametric trajectory generator, automatic interpolation, event filter, and SpatDIF-export, are newly implemented.

Figure 1.1: Klangdom installed in Kubus ZKM

1.2 Features

Zirkonium MK III has following features:

Graphical manipulation of sound trajectories with bézier curves

Zirkonium facilitates the manipulation of highly complex sound trajectories. By multi-segmented-bézier-curves, you are able to draw sound paths intuitively and flexibly.

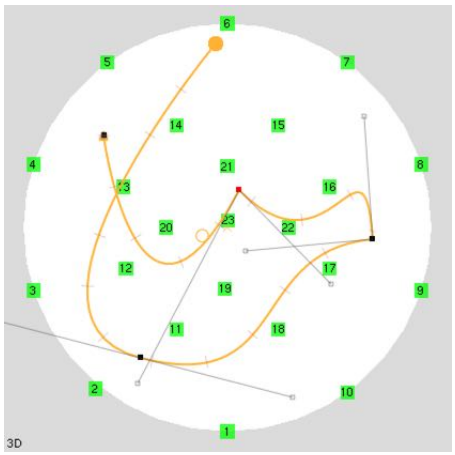


Figure 1.2: A sound trajectory drawn with bézier curves.

Parameter-based Trajectory Creation

The software offers another approach for trajectory creation. With “Add circle / spiral” popover panel, you can generate spiral or circle-shaped trajectories algorithmically by inputting a few number of parameter.

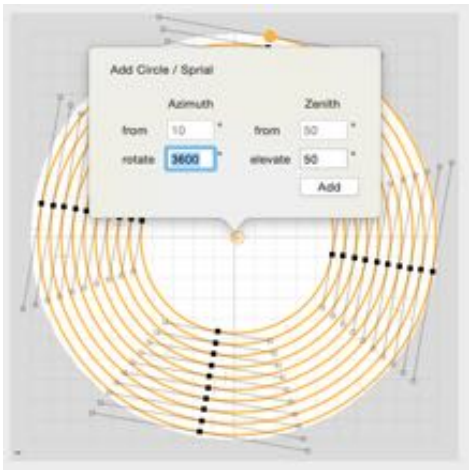


Figure 1.3: An example of parameter-based trajectory creation

DAW-like Event Handling

All imported sound files are instantly analyzed and the waveforms of the files are displayed in the manner of DAW software. Furthermore, the software allows you to create special events graphically on top of these waveforms, so that you can grasp the relationship between audio contents and spatial events at a glance.

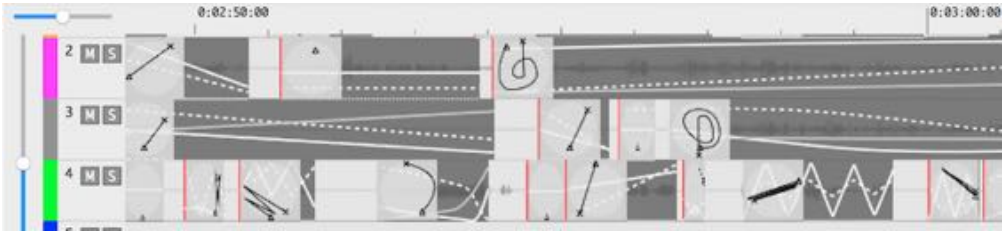


Figure 1.4: Editing Spatial Events in the manner of DAW

Event Filtering

You may sometimes want to process a large number of spatial events at once. The powerful event filtering feature of Zirkonium enables you to instantly select events, that match provided conditions, and allows you to manipulate these events at once.

Figure 1.5: Editing the condition for event filtering

Quick Event Manipulation

In Zirkonium, all events are editable with the mouse operation, but it is also possible to edit them, using text input with the **quick event manipulator**. This assists you in setting up the start time and end time of the events, or scaling the duration of the event with accuracy.

Figure 1.6: Inputting time for event time shifting in quick event manipulator

Powerful Visualization of Spatialized Sound

All waveform images of audio contents are utilized also in Dome view and Motion view. In Dome view, the waveforms are rendered along sound paths and enables you to grasp the relationship between audio contents and positions in the space.

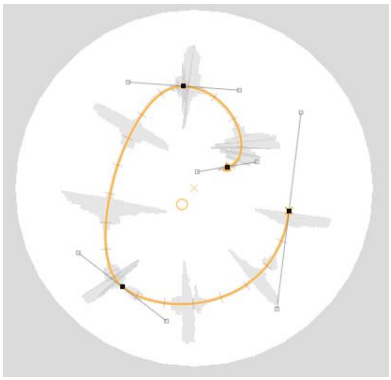


Figure 1.7: Waveform rendered along a sound path

Variety of Rendering Algorithms

Zirkonium currently features two types of spatial rendering algorithms, VBAP and Ambisonics. In Zirkonium, you are able to assign an algorithm for each ID (sound object) and employ both algorithms simultaneously. For Ambisonics, further options for optimization (*in phase* and *maxRe* optimization) are available.

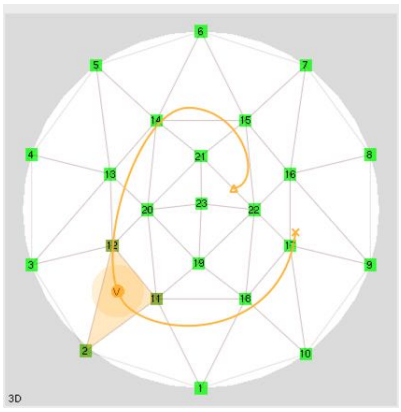


Figure 1.8: Domeview displays active VBAP speaker triplet during playback

HRTF Simulation

With the HRTF (Head Related Transfer Function) algorithm, Zirkonium realizes a virtual 3D sound for headphone listening. This functionality enables you to continue working on composition in any kind of enviroment.

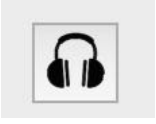


Figure 1.9: HRTF mode button

Customization of Core Spatial Rendering Algorithm

In principle, the spatial rendering algorithms in Zirkonium is optimized for 3D surround systems, such as Klangdom. However, the software grant you an access to the core spatial algorithms, written in Pd (Pure Data). By modifying this core sptatial algorithms, you could tune the core spatial algorithms up for other surround systems.

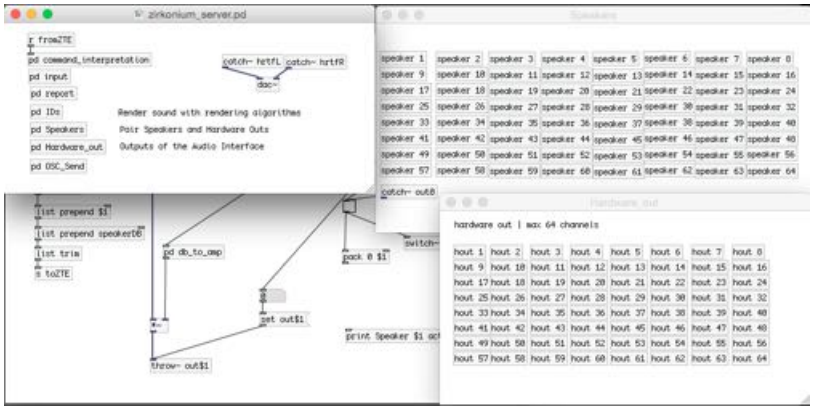


Figure 1.10: Spatial Rendering Algorithm is implemented as a Pd Patch

SpatDIF Compatibility

Zirkonium has a functionality to exports all spatial events to a SpatDIF conformed XML file. With this functionality, you can reuse trajectories and events, created with Zirkonium in other software such as Max or Pure Data.

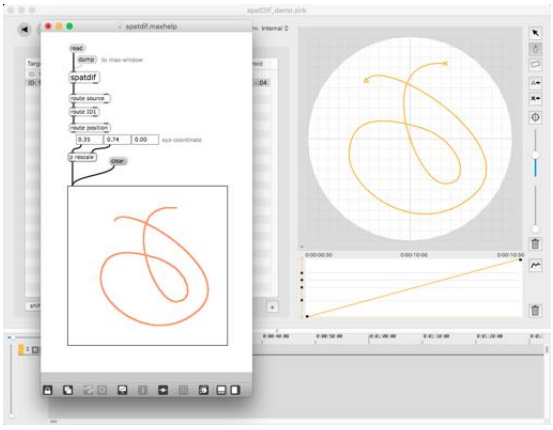


Figure 1.11: a Max patch imports a trajectory drawn in Zirkonium

Synchronization with other software through OSC or MTC

Zirkonium is able to synchronize with other software that are compatible with OSC (Open Sound Control) or MTC (MIDI Time Code) as a master or a slave. This feature is useful, when we synchronize a video file running on another application, while playing back audio from Zirkonium.

1.3 What's in the package

Other than **Zirkonium Trajectory Editor**, the main application, Zirkonium package includes two more applications, **Speaker Setup** and **ZirkoniumQTPlayer**.

Speaker Setup is an application for configuring speaker setup in a 2D or 3D space. This application is able to export a XML file that defines speaker positions in a space. These XML files can be loaded onto the Dome View of the Zirkonium Trajectory Editor for defining your own speaker setup. For details see chapter 11

ZirkQTPlayer is a simple Quicktime player that is capable of receiving OSC Messages from Zirkonium Trajectory Editor. This software enables you to synchronize sound tracks that spatialized with Zirkonium and a Quicktime Movie. For details see chapter 12.

1.4 Architecture

Figure 1.12 illustrates the software architecture of Zirkonium Trajectory Editor. All GUIs are developed with Cocoa, OpenGL and GLSL. Apple's Core Data is utilized for data management.

The spatial rendering functionalities are programmed as a Pure Data patch. This Pd patch, as well as Pure Data sound processing engine, are embedded in the Zirkonium Trajectory Editor employing libPd.

Audio signals, processed by embedded Pd, are sent to audio hardware through Port Audio and Core Audio.

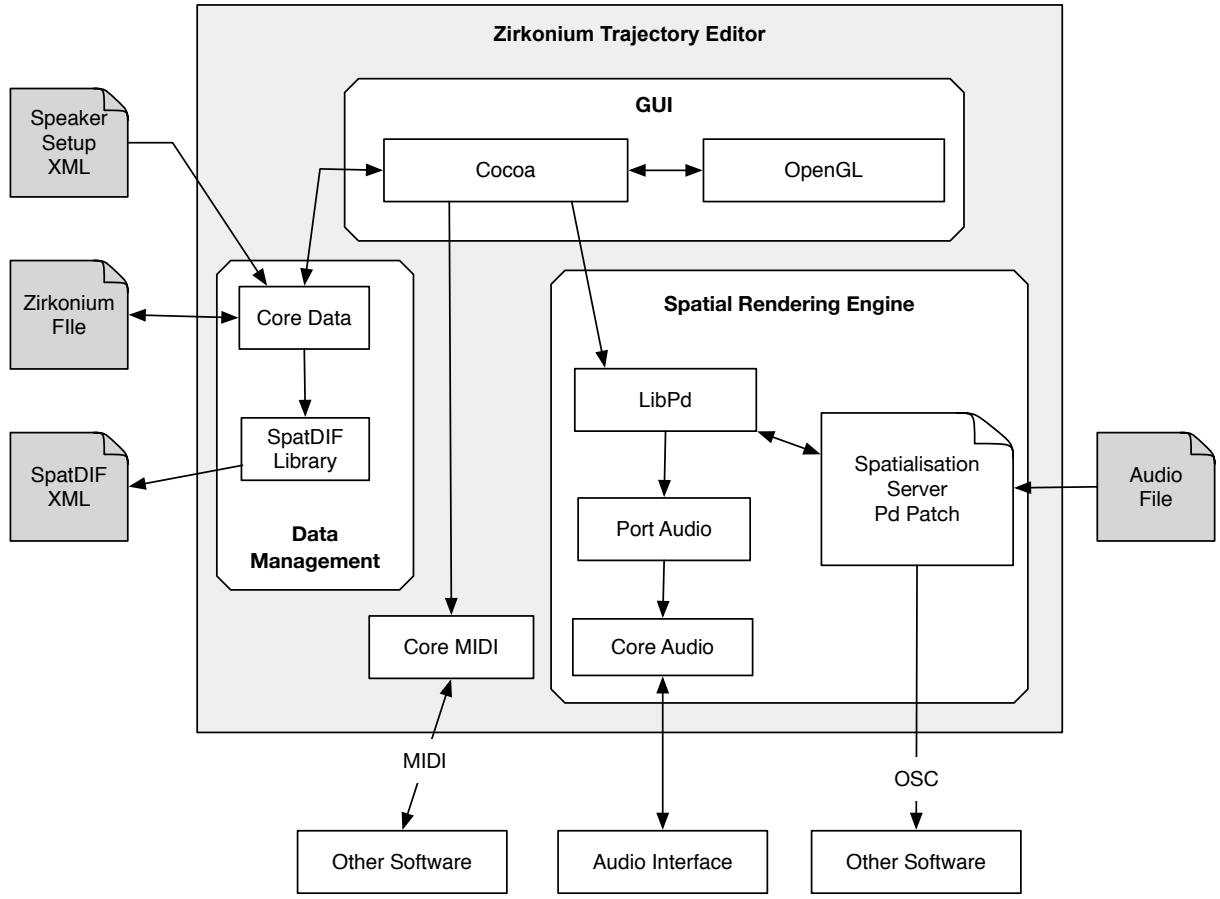


Figure 1.12: Software Architecture

1.5 Dependencies

Zirkonium employs following Open Source Libraries in addition to MacOSX Cocoa Framework:

Name	License	Author	URL
Pure Data	Standard Improved BSD	Miller Puckette	`http://puredata.info`
LibPd	Standard Improved BSD	Peter Brinkmann *et al.*	`http://libpd.cc`
SpatDIF Library	MIT	Chikashi Miyama *et al.*	`http://spatdif.org`
Port Audio	MIT	Ross Bencina	`http://www.portaudio.com`
HOA Library	GPLv3	Julien Colafrancesco *et al.*	`http://www.portaudio.com`

Table 1.1: Dependencies

1.6 System Requirement

The system requirement for Zirkonium is:

1. Operating System: 10.9 or higher
2. CPU : Intel Core i5 or i7
3. RAM : min. 4 GB

The software is tested and evaluated on Mac OS 10.11 (El Capitan).

1.7 What's in the package

In the Zirkonium package, you will find three separate applications.

1. Zirkonium Trajectory Editor
2. Speaker Setup
3. ZirkQTPlayer

Zirkonium Trajectory Editor is the main application of Zirkonium. With this software, you can compose and design spatial trajectories for up to 64 speakers. Obviously, we need to let Trajectory Editor know, where each speaker is located. For this purpose, Speaker Setup application is employed. With Speaker Setup, you can configure a 2D or 3D speaker setup and store it as a XML file. Trajectory Editor imports this XML file and use the configuration for both visualization and spatialization. ZirkoniumQTPlayer is a Quicktime player that enables you to playback a movie in sync with Zirkonium.

1.8 Installation

For the installation, simply copy all three applications to your Applications folder.

1.9 The Coordinate System of Zirkonium

There are many different coordinate system for describing a position in a 3D space. Zirkonium Trajectory Editor and Speaker Setup application adopt the head-related coordinate system, defined by Jens Blauert in his book entitled Spatial Hearing: The Psychophysics of Human Sound Localization.

In this coordinate system the relationship between the listener and **Azimuth** is defined as follows:

- Front ... 0°
- Left ... -90°

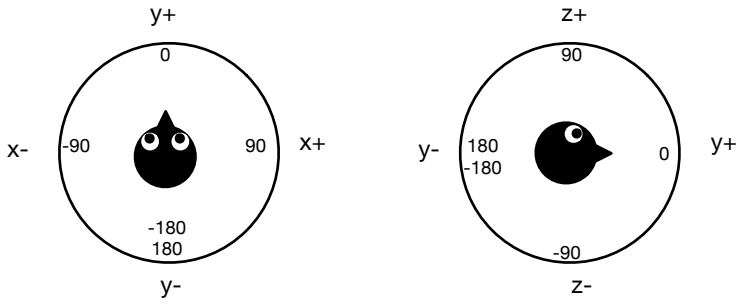


Figure 1.13: The Coordinate System of Zirkonium

- Back ... 180° or -180° or
- Right ... 90°

The relationship between the listener and the **Elevation** is defined as follows:

- Above (Zenith) ... 90°
- Below (Nadir)... -90°

The relationship between the listener and the Cartesian axes is defined as follows:

- Left ... x-
- Right ... x+
- Front ... y+
- Back ... y-
- Above ... z+
- Below ... z-

Figure 1.13 depicts the relationship between the listener and both Spherical and Cartesian coordinates used in Zirkonium.

2. GUI overview

You can create, open or reopen files using the **File -> New / Open / Open Recent** menus. After you create a new document, a new window should be appeared on screen [fig:2.1].

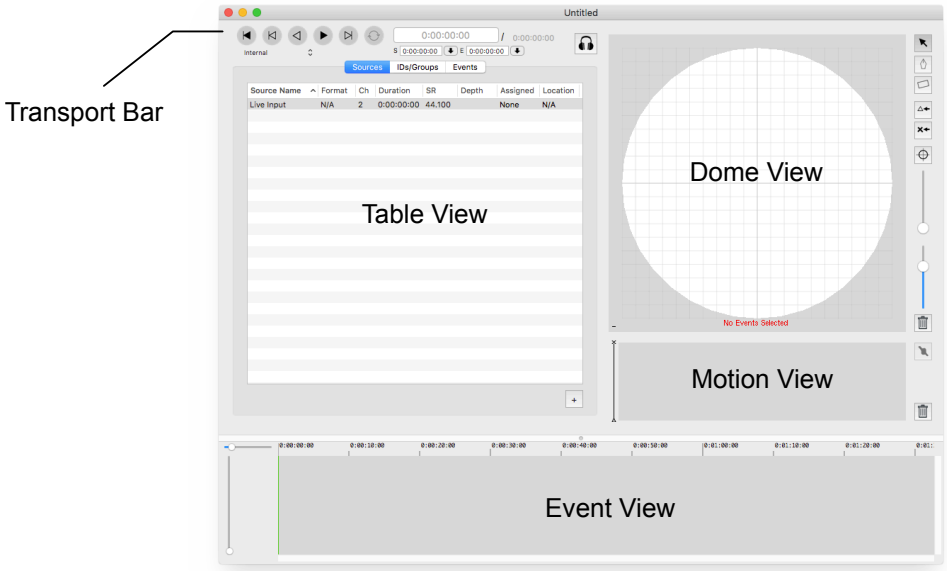


Figure 2.1: New window

The window consists of following five components.

- Table View
- Dome View
- Motion View

- Event View
- Transport Bar

In order to give some glimpse, this chapter describes the functionalities of each component briefly. For details, see chapter 4 - 7.

2.1 Table View

This view displays all data in the current project in tables. The view is comprised of three tabs; **Sources**, **IDs/Groups**. and **Events**.

Figure 2.2: Table view tab

Sources Tab

This is the start point of your spatial composition. The table in this tab lists all imported sound files. You can add new files to this list for playback or remove previously added files from the list.

IDs/Groups Tab

This tab has two tables in it. The table above is called **IDs Table** and the table below is called **Groups Table**. Here you can define IDs (sound objects) and Groups of IDs. For details of ID and Group, refer chapter 5 and 6.

Events Tab

All events of IDs, Groups and Markers in the piece is listed here. You can add, delete, or modify single or multiple events in this tab. At the bottom of the tab, there is a group of pop-up menus and text fields. This is called **Quick Event Manipulator**. This small GUI component enables you to quickly modify the properties of selected events.

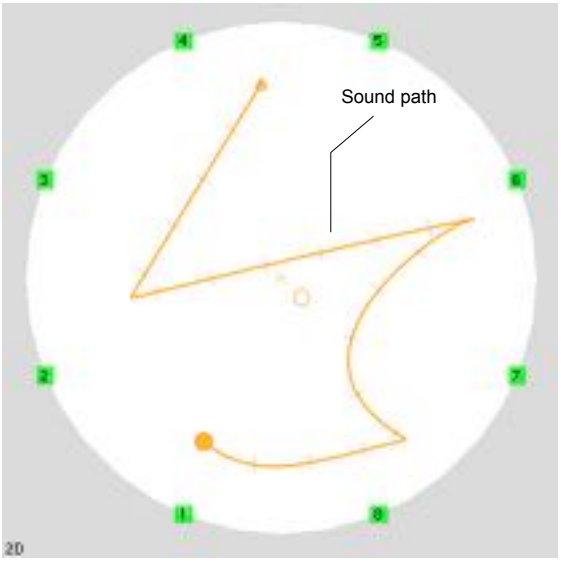


Figure 2.3: Sound path in the Dome view

2.2 Dome View

Dome View is a canvas for **Sound Path**. Using bézier curves, you can design the paths of sound trajectory for each spatial event. During the playback, this view visualizes active sound paths, the level of audio signals sent to each loudspeaker, the movement of each ID, selected loudspeaker triplets by the VBAP algorithm etc. in real-time [fig:2.3].

2.3 Motion View

In dome view, you draw paths that sound objects (i.e. IDs) move along. Obviously, a sound path has two ends, start point and end point. However, it does not necessary means that all IDs move from start point to end point in a *constant* speed. In Motion view, you can draw a **Motion path** that determines how IDs move along the corresponding sound path. Furthermore, this view provides also the control over **Span Path** that represents the spatial expansion of each ID in time.

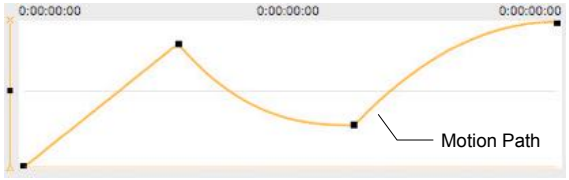


Figure 2.4: Motion path in the Motion view

2.4 Event View

This View shows all spatial events in the manner of DAW-software. The X-axis represents the time line. Events assigned to each ID are represented as gray rectangles in the view, and the movements of each ID are displayed as white solid and dotted lines in the rectangles. The thumbnails of corresponding sound paths are rendered on top of them.

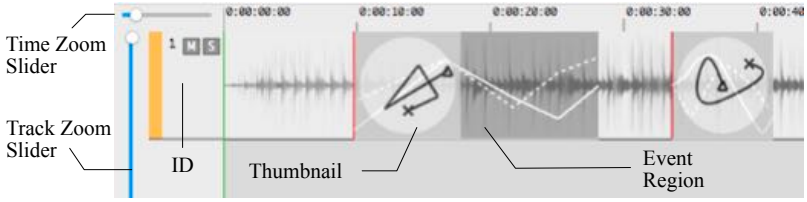


Figure 2.5: Events displayed in Event View

2.5 Transport Bar

Transport bar consists of four buttons, two text fields, and the HRTF button. the functions of each button are described below:

Rewind Button

set the position of playback cursor to 0:00:00:00.

Jump To Previous Marker

Set the current time to the time of the previous marker. if no previous marker is found, jump to 0:00:00:00

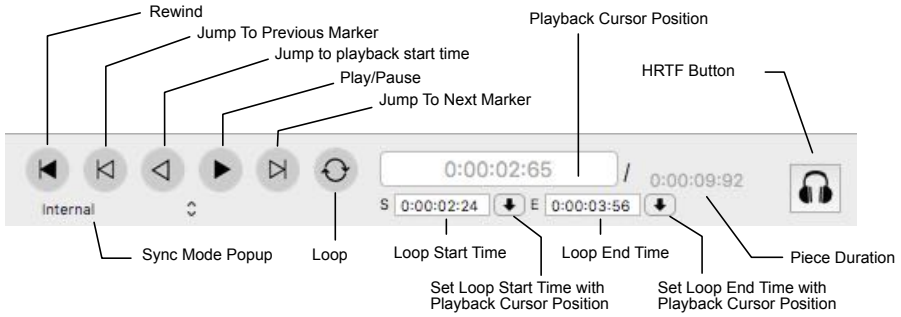


Figure 2.6: Transport Bar

Jump To Playback Start Time

Set the current time to the start time of the previous playback. This is useful if you want to listen to the previously played part once again. In the event view, this time is indicated with the vertical dark green bar.

Play/Pause Button

When clicked, Zirkonium starts to play the piece back from the position, where the playback cursor is located. It pauses the playback, when it is clicked again.

Jump To Next Marker

Set the current time to the time of the next marker. if no next marker is found, jump to the end of the piece.

Loop

This is a toggle button. If activated, the playback is looped between the loop start time and the loop end time.

Playback Cursor Position

This field indicates the position of the playback cursor. This field is editable and you can input a time that you would like to jump to.

Loop Start Time

This field displays the start time of the loop.

Set Loop Start Time with Playback Cursor Position

Copy the current time indicated in the Playback Cursor Position field to the Loop Start Time field.

Loop End Time

This field displays the end time of the loop.

Set Loop End Time with Playback Cursor Position

Copy the current time indicated in the Playback Cursor Position field to the Loop End Time field.

Piece Duration Field

This field shows the duration of the piece. Zirkonium determines the duration of the piece automatically by comparing the end time of the last event and the duration of the longest sound file, and adopts the longer one as the piece duration. This field is not manually editable.

HRTF Button

This button with headphones icon is called **HRTF button**. When enabled, all audio signals are fed to the HRTF possessors, and simulate virtual 3D audio for headphone listening. The processed sound is sent to channel 1 and 2.

Sync mode pop-up

With this pop-up menu, you can select synchronization mode. Refer chapter **??** for details.

3. Setting up

3.1 Setting up loudspeakers

After launching the software, The first thing we need to do is to tell the software the position of each loudspeaker in a space.

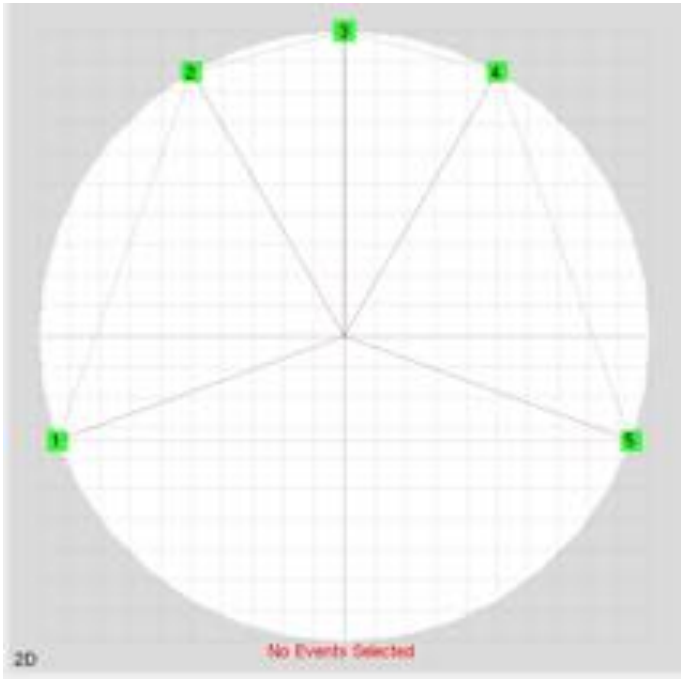


Figure 3.1: 5.0 Speaker Setup loaded on Dome View

3.1.1 Standardized Speaker Setup

To set up standardized loudspeaker configurations, such as stereo, quadraphonic, or 5.0 [fig:3.1], simply select a speaker setup from **File -> Load Speaker Setup**.

3.1.2 Custom Speaker Setup

If you would like to use speaker configuration, not listed in the Load Speaker Setup menu. Use the **Speaker Setup** Application for configuring your own setup and exporting the configuration as a XML file. For details, refer the chapter 11 of this user guide.

By selecting "Load from XML File..." menu under Load Speaker Setup, you can load your original speaker configuration to Dome view.

3.2 Audio Settings

The detailed properties for each input channel can be configured with Audio Settings sheet. To open this sheet, select **File -> Audio Settings**.

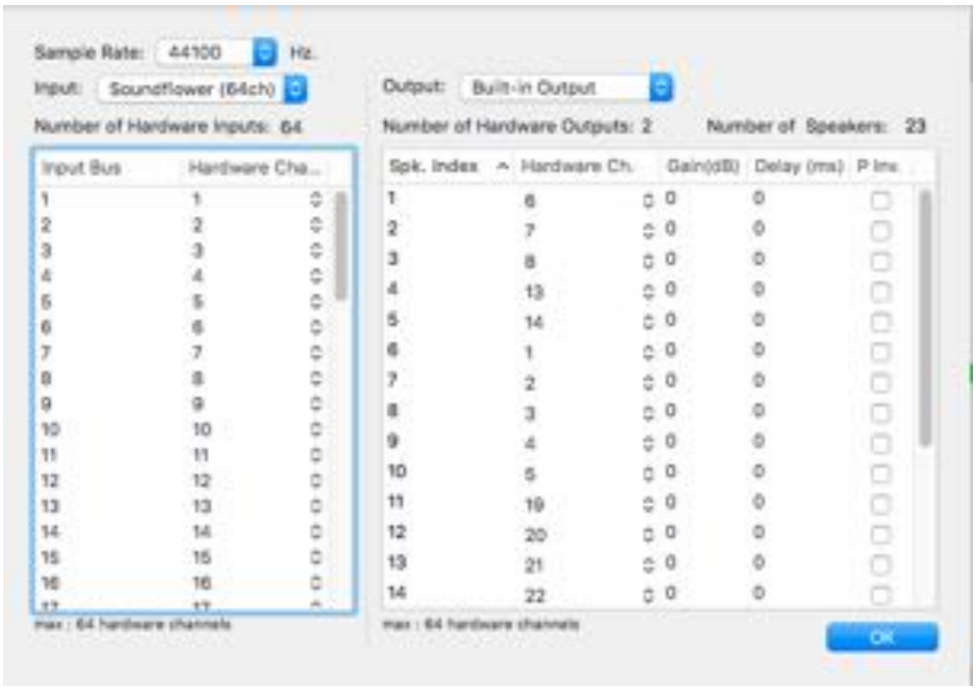


Figure 3.2: Audio Setting Panel

The following is descriptions of each items in the sheet.

3.2.1 Sample Rate Pop-up

Select sample rate from **44100**, **48000** or **96000** Hz, using this pop-up menu. It is highly encouraged to setup the sample rate before importing sound files to the software.

3.2.2 Input Device Pop-up

Select a hardware device for audio input from the pop-up menu. You can receive audio signals not only from physical devices connected to the computer but also other software running on the computer by installing Soundflower or similar utilities.

3.2.3 Output Device Pop-up

Select a hardware device for audio output from the pop-up menu

3.2.4 Input Patch Table

This table determines the relationship between the Hardware inputs and virtual input buses. This is useful when your hardware offers a large number of inputs and you wan to use for example channel 128 of your hardrware.

The input bus determined in this table are used as the channel of you select "Live Input" as the source of an ID.

Input Bus The input bus to which the selected Hardware channel is connected

Hardware Chennel Pop-up button The hardware channel that connected to the input bus

3.2.5 Speaker Property Table

With this table, you can configure the following parameters for each speaker. This table is empty unless you load a speaker setup onto the domeview.

Index The index of speaker defined in Speaker Setup XML File. This parameter is not editable.

Output Channel Output channel of audio hardware (e.g. your audio interface) assigned to each speaker.

Gain The gain of the speaker in dB. 0 means Unity (bypass). The range of this parameter is between -30 and +10.

Delay Delay time applied to the speaker for delay. This parameter is useful for avoiding comb-filter effects caused by irregular speaker setup.

Phase inversion If checked, Zirkonium inverts the signal output of the specified speaker.

4. Importing sources

4.1 What is Source

In Zirkonium, the term **source** represents all kinds of audio data that can be utilized for spatialization. A source can be in a form of sound file, such as “my sound.wav” store in the hard drive, but it can be also a live signal directly coming from an audio interface, attached to your computer.

4.2 Sources Table

The source table lists all available sound sources. Each column of the table describes properties of sources [fig:4.1].

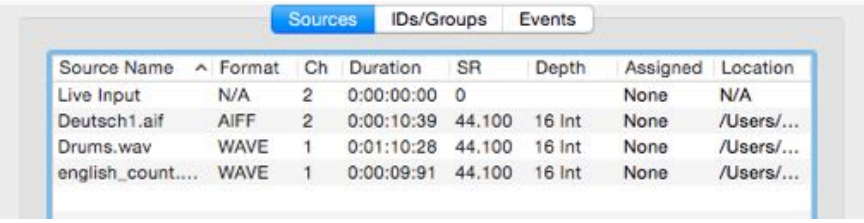


Figure 4.1: Sources Table

Source Name

The name the imported audio file

Format

The format of the imported audio file. WAVE or AIFF

Ch

The number of audio channels

Duration
The duration of the audio file in *h:mm:ss:ms* format

SR
The Sample Rate of the file

Depth
The Bit Depth of the file (Usually 16, 24 or 32 bits)

Assigned
IDs that currently use this file

Location
The full path of the file

R **Live Input** represents the audio input from your audio interface or microphones attached to or embedded in your computer. This entry in the table is not removable from the source list.

In case you use software that transfer audio signal from one application to another application such as SoundFlower, select "Live Input" for receiving audio signal from the software.

R Zirkonium creates the waveform images of the sound files, when they are imported. It may take several seconds for this process, depending on the sample rate and the duration of the files.

4.3 Adding and Removing Files

To add source file(s) to the project, simply drag and drop sound files(s) on to “Sources” table, or click the “plus” button below the table and select files from the open panel. Multiple files can be added at the same time.

To remove source file(s) from the source table, simply select files in the list and press delete key.

4.4 Acceptable File Formats

Zirkonium currently accepts sound files that has following properties:

Number of Channels
- 1 - 8

File Format
- AIFF
- WAV

Sample Rate
- 44.1 kHz
- 48 kHz
- 96 kHz

Bit Depth

- 16 bit
- 24 bit
- 32 bit

The sample rate of the file must conform to the sample rate of the project file. If the sample rate of the file does not match the sample rate of the project, these files are not assignable to IDs.

To change the sample rate of the project refer chapter 3.2.

> You can remove a sound file assigned to an ID from sources table. If you remove, the associated IDs lose the connection to sound file, but it remains in the IDs list. The events associated to an ID are also retained in the event table for reuse.

5. Creating IDs

5.1 What is an ID?

ID means “sound object” in Zirkonium. Before you move your sound sources in a space, you need to create ID(s) and assign a source (sound file or live input) to it.

> In Zirkonium, the number of channel that is assignable to single ID is always **one** (i.e. mono). If you want to move a stereo source in a space, import a stereo file, create two IDs, assign each ID to each channel of the imported stereo file, and group them together using grouping functionality described in chapter 6.

5.2 IDs Table

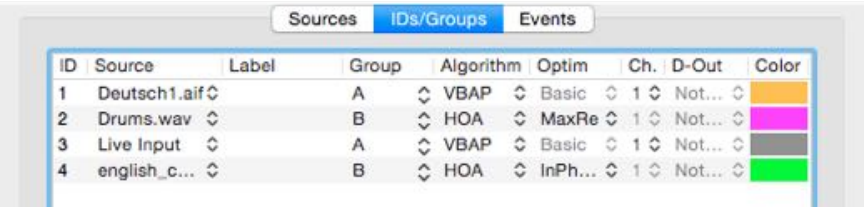


Figure 5.1: IDs Table

The **IDs table** ,located at the top of the IDs / Groups tab, shows all IDs in the project and displays the properties of each ID listed below[fig:5.1] :

ID

The index of ID assigned automatically by the software. This value is not editable.

Source

The audio source (sound file or live input) assigned to the ID.

Label
The name of ID.

Group
The group that this ID belongs to.

Algorithm
The spatial rendering algorithm assigned to ID.

VBAP Vector Based Amplitude Panning (Default).
HOA Higher Order Ambisonics.
OSC Open Sound Control. If this option is selected, Zirkonium does not process the audio signal and simply send the position of ID as OSC messages. This option is useful, if you want to control another software or hardware with Zirkonium.
None doesn't output any audio signals or OSC messages from this ID, unless D-out (Direct Out) is activated.

Optim
Optimization option for HOA Spatial rendering algorithm.

When HOA (Higher Order Ambisonics) is selected as the spatial rendering algorithm, an optimization option for the algorithm becomes selectable and you can choose one of the following optimization option. The definition of three optimization options by the CICM (the developer of HOA library) are as follows.

Basic has no effect, it should be used (or not) with a perfect Ambisonics channels arrangement where all the channels are to equal distance on a circle or a sphere, and for a listener placed at the perfect center of the circle of the sphere
MaxRe should be used for an auditory confined to the center of the circle of the sphere.
In Phase should be used when the auditory covers the entire channels area and when the channels arrangement is not a perfect circle or a perfect sphere or when the channels are not to equal distance.

> The order of Ambisonics is optimized automatically by the software, based on the number of loudspeakers; higher number of loudspeakers requires higher Ambisonics order. Thus, CPU consumption by HOA may increase with higher number of loudspeakers.

Ch
The channel assigned to ID. The pop-up is disabled, when the source is mono.

D-Out
The Direct Out. When assigned, the source signal will be routed direct to the selected output of the audio hardware.

> D-Out is useful, when you want to send a source sound to single specific speaker or send source to another external processor.

Color
The color that represents each ID. When this cell is clicked, a color picker floating window should be appeared and let you choose the new color for the ID.

5.3 Creating a new ID

To add an ID to Trajectory Editor. First make sure that you are in the “ID/Groups” tab, and click the “+” button below the upper table to add a new ID.

When an ID is added to the IDs table, an **initial event** is created and set the position of ID to (0, 0).

> This initial event is not removable from event table manually and the most of properties of initial event is not modifiable by the user except **initial position**. An initial event is automatically removed, when the corresponding ID is removed from the IDs table.

5.4 Assign a source file to an ID

Simply click on the pop-up menu and select the source, you want assign to.

5.5 Deleting ID(s)

To delete ID(s), Select one or multiple ID(s) listed in the IDs table and press the delete key.

Be careful. All spatial events that has association with the deleted ID will be also deleted from the event list.

6. Bundling as Groups

6.1 What is a Group?

Group represents a set of multiple IDs moving together. Grouping function allows us to move several IDs along single sound path. All IDs, belonging to a Group, are called **member IDs** of a group. A group must have single **Master ID**. The IDs in a group other than Master ID is called **Slave ID**. The Master ID moves along the sound path and each slave ID follows the master ID, keeping the distance or angle between them [fig:grouping].

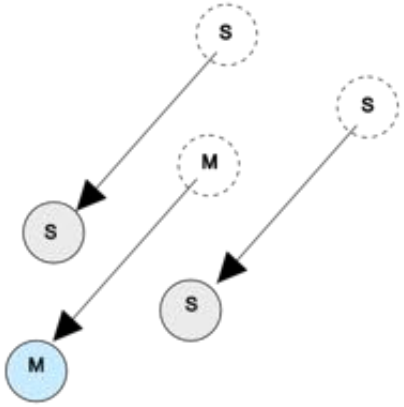


Figure 6.1: Grouping

R A group must have one master ID. You are able to draw a sound path for a group, only if the master ID is assigned. The Master ID can be selected in Groups table.

6.2 Groups Table

The Groups table shows detailed properties of each group.

Figure 6.2: Groups Table

Label

The name of each group. It is highly encouraged to provide each group with a proper name.

Member IDs

The column displays IDs that belong to the group. Not editable.

Master ID

The leading ID of the group

Mode

The mode of the group. This mode determines how Slaves follow the Master ID. discussed in 6.11 in detail.

Translate-Fixed During a group event, the Cartesian distance between the master ID and all slave IDs are determined by the Cartesian distance of initial position.

Rotate-Fixed During a group event, the spherical distance between the master ID and all slave IDs are determined by the spherical distance of initial position.

Translate-Free During a group event, the Cartesian distance between the master ID and all slave IDs are determined by the Cartesian distance of the end point of the latest independent master and slave events.

Rotate-Free During a group event, the spherical distance between the master ID and all slave IDs are determined by the spherical distance of the end point of the latest independent master and slave events.

Mirror The number of members of this mode must be two. The position of slave equals to the position of the master mirrored around Y axis.

6.3 Creating a Group

To create a group, click the “+” button below Groups table. Then, a single group should be appeared in the table.

6.4 Naming a group

To name a group, double click on the label cell of a group and type the name in. The name should be settled, when the return key is pressed.

6.5 Adding a member to a group

To add an ID to a group, assign an ID to a group by selecting group in the ID table.

6.6 Removing a member from a group

To remove an ID from a group, select another group or "unset" in the ID table. Note, you can not remove the master ID from a group. If you want to remove the master ID from a group, change the Master ID in the group table first then remove it.

6.7 Setting a Master ID

To select a master ID of a group, click on master ID pop-up cell in the group table, and select an ID from member IDs. A sound path for a group cannot be drawn, unless a master ID is assigned.

6.8 Selecting the group Mode

To select a group mode, click the pop-up menu and select one from four modes. The difference between four modes are described below.

6.9 Changing a group an ID belongs to

To change a group that an ID belongs to, simply select an another group in ID table. To disengage an ID from a group, select “unset” from the pop-up.

6.10 Deleting a Group

To delete a group, select a group or groups in the list and press the delete key.

> When you delete a group. All events that controls the deleted group will lose their target but remain in the event table. Later you can associate these events with another ID or Group.

6.11 Which group mode to select

You can select a group event mode from 5 modes. If all member IDs of a group are not moved individually by single ID events at all, there is no difference between fixed and free mode.

6.11.1 Translate and Rotate

In the translate modes (Translate-Fixed or Translate-Free), the Cartesian distance between each ID and master ID is kept unchanged and the size of group is constant. However, the relationship between IDs and the listener varies, depending on the position of the group. As the figure 6.3 shows, the group creates a narrow stereo image, if it is placed in front of the listener, but it realizes a vertical sound image, if it is moved to the left or right side of the listener.

On the contrary, in the rotate modes (Rotate-Fixed or Rotate-Free), the spherical distance (or angle) between each ID and Master ID is kept unchanged. You can take full advantage of this mode, if you move the group in circle manner (rotate around the center).

This mode causes two possibly unnatural side effects. Firstly, in this mode, the Cartesian distance or the size of a group is changed, depending on the elevation. If a group moves towards the zenith, the distance between IDs shrinks, and if a group moves towards the horizon, the distance between IDs expands. Secondly, the formation of a group will be mirrored if the group travel through the zenith.

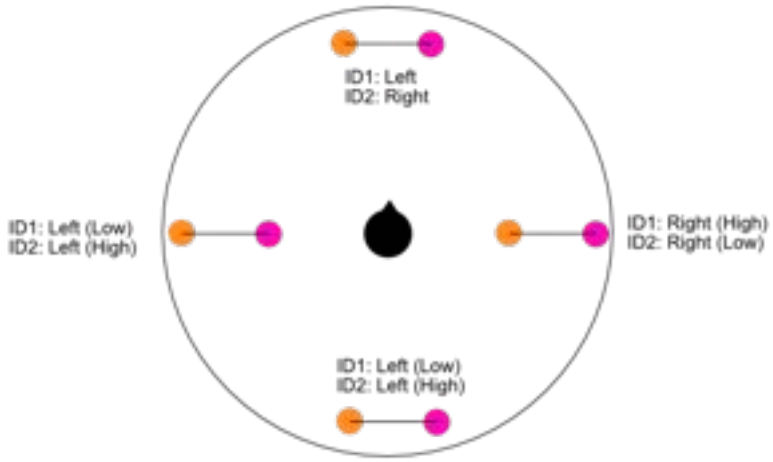


Figure 6.3: Translate Mode

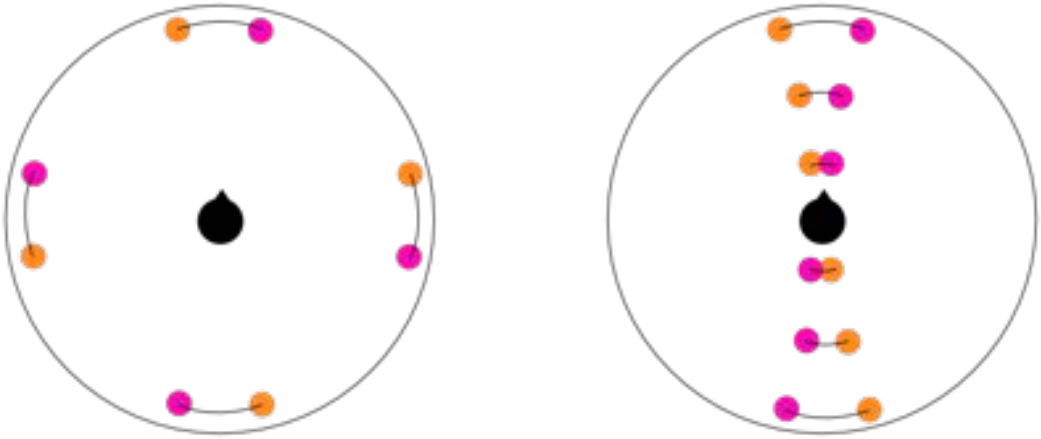


Figure 6.4: Rotate Mode

6.11.2 Fixed and Free

In the fixed mode, the Cartesian or spherical distance between the master ID and each slave ID is determined by the initial position of IDs; The only way to change the formation of the group is to change the initial ID position. The formation is not disturbed by the individual movement of member IDs. At the beginning of each group event, the formation is reset to the initial formation. This mode is useful, if you want to keep the formation of a group unchanged throughout a piece.

In the free mode, the Cartesian or spherical distance between master and each slave ID is determined by the end position of latest individual single ID event. This mode is useful, if you want to change the formation of a group in a piece.

6.11.3 Mirror mode

The Mirror mode is a special mode and different from other four modes. The number of members in a mirror-mode group must be 2 and assign a master. The position of slave ID is always mirrored around the Y axis. If the position of the master is (x, y) the position of slave is always (-x, y).

Because of this exceptional behavior of the slave, there is no distinction between fixed and free for this mode (Fig. 6.5).

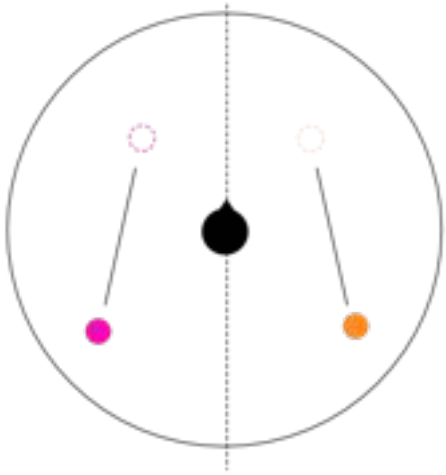


Figure 6.5: Mirror Mode

R The mirror mode is useful when you want to keep the stereo image of the sound sources always in front or back of the audience.

7. Managing events

7.1 What is an Event

In Zirkonium, all spatial movements of IDs and Groups are called **Events**. Usually an event has a start time and an end time.

An event has several properties that are related to either time or space. To edit the time-related-properties, such as start time and end time, we use **event view** or **table view**. To edit the space-related-properties, such as sound path or motion path, we use **dome view** and **motion view**.

There are two special types of events; **initial event** and **marker event**. Initial events determine the initial position of each ID. A marker event represents a certain time point of the piece, for example the beginning of each section, and doesn't process spatial properties.

7.2 GUI Overview

7.2.1 Event Table

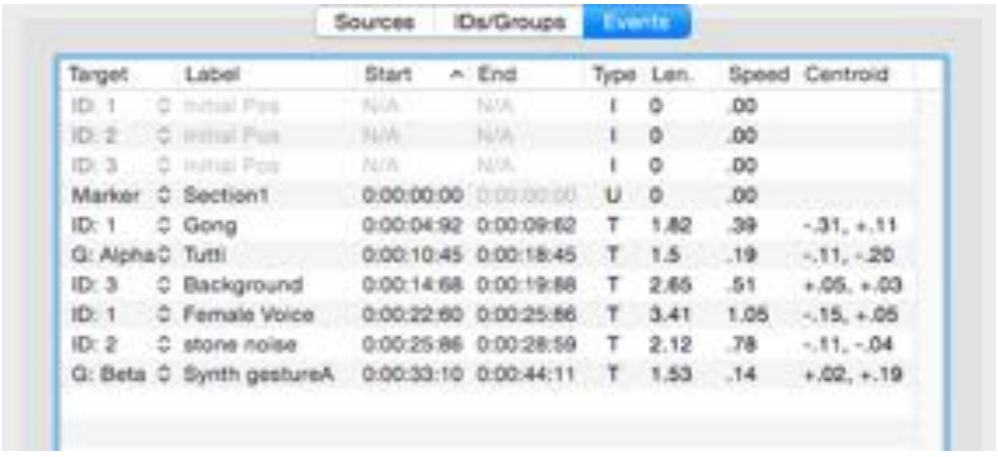


Figure 7.1: Event Table

Click the "Event" tab to display the event table. In the event table, all events are listed chronologically. You can directly modify some of the properties in the table. The descriptions of the properties are as follows.

Target

You can select the target of each event from marker, IDs and Groups with a pop-up button. The default setting is "No Value".The dome view and motion view are disabled unless you select an ID or a Group target.

Label

The name of each event. This label will be displayed in the dome view, if the visibility of the event name is enabled.

Start Time

The start time of the event in *h:mm:ss:ms* format. You cannot set a time after the end time.

End Time

The end time of the event in *h:mm:ss:ms* format. You cannot set a time before the start time. This cell is disabled when "marker" is selected as the target.

Type

The type of each event indicated with a letter, U, I or T.

undefined (U) An undefined event has no anchor points. The event doesn't move the position of IDs at all.

instantaneous (I) An instantaneous event has only one anchor point in its sound path and the ID moves to the position of the anchor point instantly when the play cursor reaches the start position of the event.

trajectory (T) A trajectory event has more than one anchor point in its sound path and the ID moves in principle from the start to end position.

Len.

The length of the path, where the radius of the unit circle = 1.0.

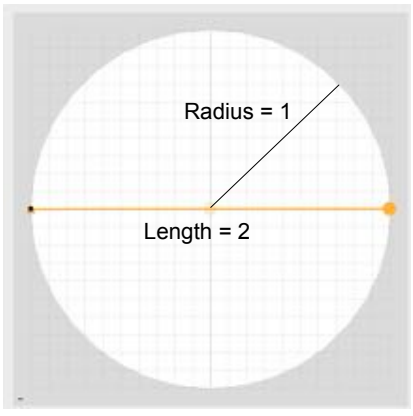


Figure 7.2: Length of a sound path

Speed

The average speed of the trajectory.

Centroid

Zirkonium internally converts (rasterizes) the sound path, drawn with Bézier curves to a large number of points, in order to optimize playback. At the same time, it calculates an average coordinate of these points. This average coordinate is called **Centroid** and it indicates the approximate spatial center of the sound path.

7.2.2 Dome View

The Dome View is the main canvas of the Zirkonium. Here you can draw sound paths freely with Bézier curves.
The most important GUI elements of the Dome View are listed below.

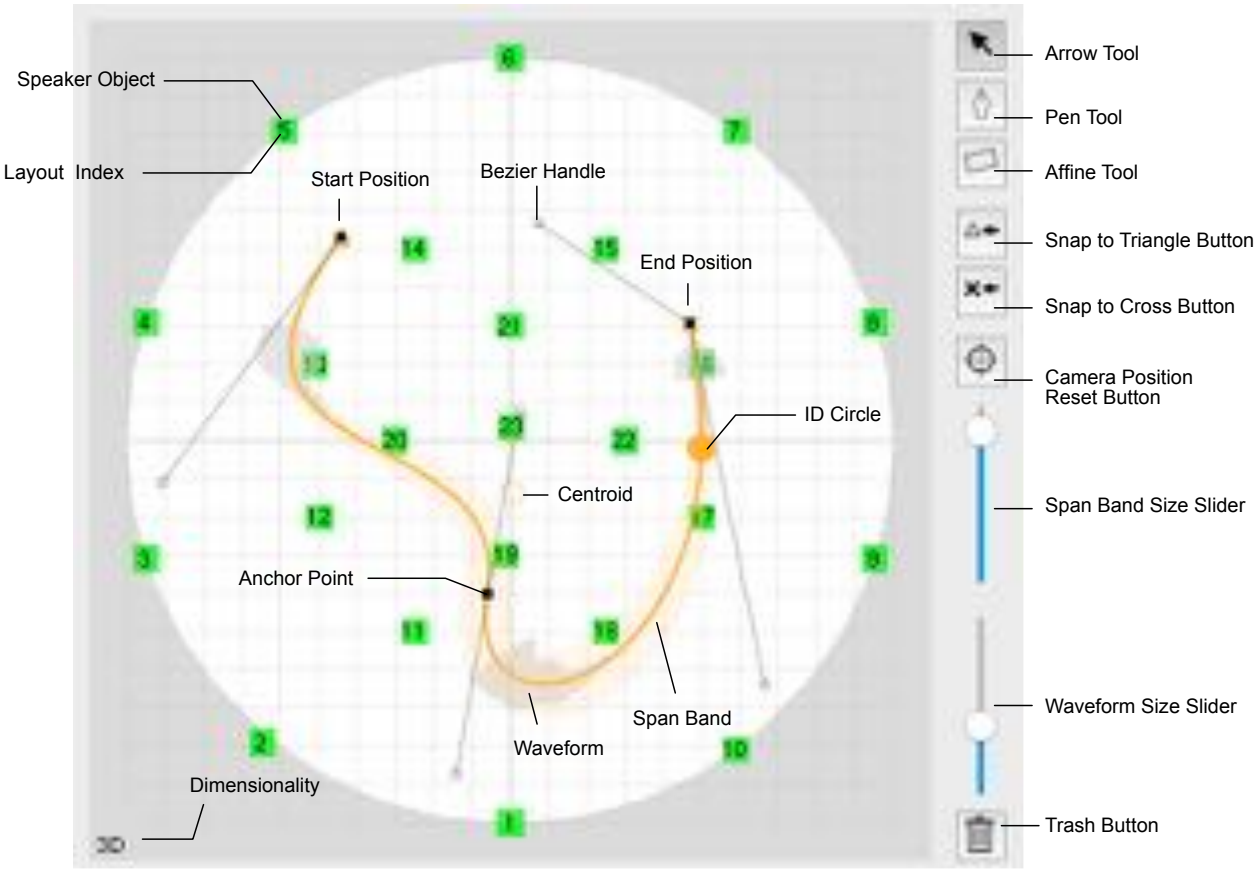


Figure 7.3: Dome View

Speaker Object

The position of Speakers are indicated as green squares and the layout indices defined in the loaded Speaker Setup XML file are shown in it.

Dimensionality

This shows the dimensionality of current speaker setup. The dimensionality is defined in the Speaker Setup XML file and not modifiable in Trajectory Editor. The CPU resource consumption significantly increases, if the 3D setting is utilized.

Sound Path

The actual path of sound that an ID moves along. The color of sound path is determined by the color of ID. The followings are graphical symbols attached to a sound path.

Start / End Position The triangle symbol indicates the start position of a sound path, and the cross symbol indicates the end position. At the start time of an event, an ID start to move from the start position, and it reaches the end position at the end time of the event.

ID Circle This circle indicates where the ID is currently located along the sound path.

Centroid The center of the trajectory.

Waveform The audio content of the associated source file.

Span Band The size or expansion of the ID represented as a band.

Anchor Point represented as solid black squares. These are "joints" of multiple Bézier curves.

Bézier Handles these handles are used to control the bends of each Bézier curve.

Arrow Tool

When selected, you can select items in the dome view, motion view and event view.

Pen Tool

When selected, you can add anchor points in the dome view or motion view and event regions in the event view.

You can switch Arrow Tool and Pen Tool quickly by a keyboard short-cut, Cmd+E.

Affine Tool

When selected, you are able to translate, rotate and scale the sound path in the dome view.

Snap To Cross Button

The start position of the currently selected sound path will be matched to the transparent cross (i.e. the end position of the sound path of the previous event). By matching these two points, you can avoid abrupt jumps of the ID position.

Snap To Triangle Button

The end position of the currently selected sound path will be matched to the transparent triangle (i.e. the start position of the sound path of the next event). By matching these two points, you can avoid abrupt jumps of the ID position.

Camera Position Reset Button

Reset the camera position.

Span Band Size Slider

This slider controls the size of the span band displayed in the dome view. Note, this slider modifies only the visual representation of the span and doesn't change the actual span path.

Waveform Size Slider

This slider controls the size of the waveform attached to the sound path. Note, this slider modifies only the visual representation of the waveform, and doesn't change the actual amplitude of audio content.

Trash Button

When clicked, the sound path, shown in the dome view, will be deleted instantly.

Visibility Control

The visibility of each GUI component is configurable with the Dome view menu under view menu. Dome menu has three sub-menus: plane, speaker and sound path. The details of each menu items are listed in the table 7.1 - 7.3.

Grid	show/hide the 10x10 grid in the dome view

Table 7.1: Plane Sub Menu

Object	show/hide the speakers. The speakers are depicted as green squares in the dome view.
Index	show/hide the layout index number of each speaker
Output	show/hide the hardware output number associated to each speaker
Ring	show/hide the rings (speaker groups)
Triplet	show/hide the loudspeaker triplets and currently selected triplet used in VBAP algorithm
Gain	show/hide the gain of each speaker
Level	if activated, the output level of each speaker will be visualized with color

Table 7.2: Speaker Sub Menu

Waveform	show/hide the waveform displayed along a sound path
Ruler	show/hide the ruler
Centroid	show/hide the geometrical center of the sound path
Event Name	show/hide the name (label) of event that the sound path belongs to

Table 7.3: Sound Path Sub Menu

7.2.3 Motion View

The motion view is an editable line graph that represents the relationship between time (X-axis) and the relative position of an ID along a sound path (Y-axis).

As written above, a sound path has a start position and an end position, which are marked with a triangle and a cross symbols respectively. The perpendicular line close to the left edge of the view, called Mini-Sound Path, represents the tightened up version of a sound path, drawn in the Dome View.

The descriptions of graphical components in Motion View are as follows:

Start Time

The start time of selected event.

Duration

The duration of selected event.

End Time

The end time of selected event.

Mini-Sound Path

This is a tightened-up representation of a sound path drawn in the dome view. The start position of a sound path corresponds with the bottom end, and the end position corresponds with the top end of the Mini-Sound path. The Mini-Sound Path also displays the relative position of anchor points on the sound path.

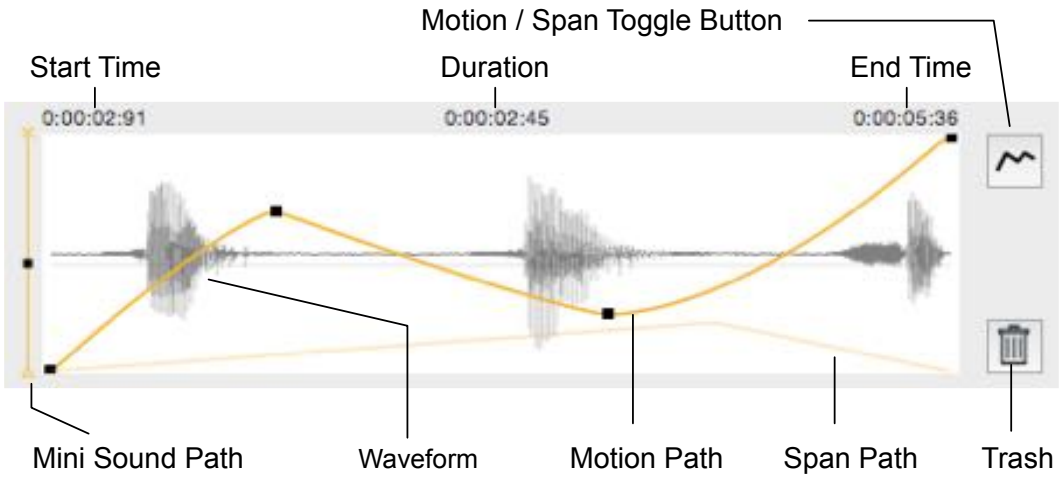


Figure 7.4: Motion View

Motion and Span Path

if the motion mode is selected, a motion path for a selected event is shown in the view. If not, the span path is displayed. These modes can be switched by pressing Motion / Span toggle button.

Waveform

The waveform of an audio content to be played during selected event.

Motion Span Toggle Button

You can toggle motion and span mode by clicking this toggle button.

Trash Button

When clicked, both motion and span path will be reset.

Visibility Control

The visibility of each GUI component is configurable with the Motion view menu under view menu.

Waveform	show/hide the waveform displayed behind the motion / span path
Ruler	show/hide the ruler
Anchor Points as Lines	show/hide horizontal lines from the anchor points on the Mini-Span Path

Table 7.4: Motion View Visibility Control

"Anchor points as Lines" function is useful to adjust a certain audio content and a position on a motion or span path. For details refer 7.6.2.

7.2.4 Event View

The Event view visualizes the created event graphically in the manner of DAW-Software. You can edit the time-related properties, such as start time or end time of events directly here in the event view. The detailed description of each graphical component are as follows:

ID

Each track represents the audio content and the movements of an ID. The number of each ID is displayed next to the ID color bar.

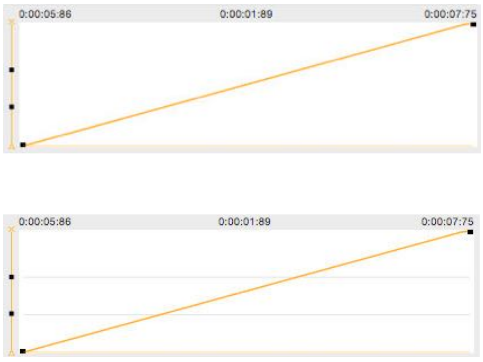


Figure 7.5: Anchor Points as Lines disabled and enabled

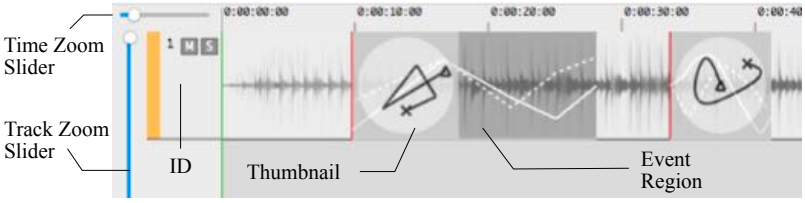


Figure 7.6: Event View

Mute / Solo Button

Like DAW software, you can temporarily mute a specific ID by clicking “M” (Mute) button or you can mute all other tracks by clicking “S” (Solo) button.

Time Zoom Slider

This slider controls the horizontal zoom factor of the event view.

Track Zoom Slider

This slider controls the vertical zoom factor of the event view.

Waveform

Actual audio content of the associated source file.

Event Region

In the event view, events are represented as dark rectangles called **event regions**. On top of event regions, thumbnails, XY-Movement Lines, and Jump Warning lines are displayed.

Thumbnails A small snapshot of the sound path

XY Movement - Span Lines The solid white line displays the movement of ID on X axis, the dotted white line shows the movement of ID on Y axis. The Grey solid line indicates the transition of the span.

Jump Warning Line The red line at the left edge of each event region warns you that the listener might perceive an unnatural abrupt sound movement (i.e. jump) at the moment of the red line, due to sudden change of the ID position.

Visibility control

The visibility of each GUI component is configurable with the Event View menu under view menu.

SoundPath	show/hide lines that indicate the movement of ID on X and Y axes
Thumbnail	show/hide thumbnails of sound paths

Table 7.5: Event View Visibility Control

7.3 Navigating the playback cursor

Zirkonium offers several ways to navigate the playback cursor.

7.3.1 Playback Cursor Position Field

The first option would be the Playback Cursor Position field. Simply set a time in *h:mm:ss:ms* format in the field. Then, the green playback cursor jumps to the provided time instantly.

Figure 7.7: Navigating playback cursor with the playback cursor position field

7.3.2 Markers

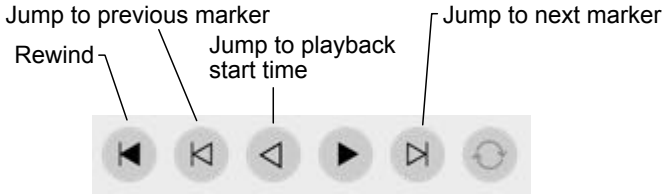


Figure 7.8: Navigating playback cursor with the cursor position field

You can easily jump to specific points of time, using “jump to previous marker” or “jump to next marker” button in the transport bar.

The rewind button instantly set the playback cursor position to 0:00:00:00.

7.3.3 Jump to playback Start Time

When you start playback, Zirkonium automatically stores the time point that the playback began. This time point is indicated with a vertical dark green line in the event view (Fig. 7.9).

After the playback, if you want to hear once again the same part of your piece. Simply click the Jump to playback start time button (or Cmd+R). Then the playback cursor immediately jumps to the position where the previous playback started.

7.3.4 Loop Playback

Zirkonium Trajectory editor offers also a loop playback function, if you want to listen to a specific part of your music repeatedly. In order to specify the loop start and end time, use the loop start / end field under the Playback Cursor Position field.

You can enter the loop start / end time by typing time in *h:mm:ss:ms* format or, use Set Loop Start/End Time with Playback Cusror Position button to copy the current time to the field.

The loop start and end times are indicated with red lines in the event view.

Then, activate the loop mode by clicking loop button and press play button. To deactivate the loop mode, click the loop button again.

Figure 7.9: Playback start time is indicated with a thin dark green line in the Event View

Figure 7.10: The transport bar with the activated loop button

7.3.5 Time Ruler

There is a time ruler above the event view. You can click on the time ruler to adjust the position of playback cursor. By double clicking on the time ruler, you can also start playback from the clicked position immediately.

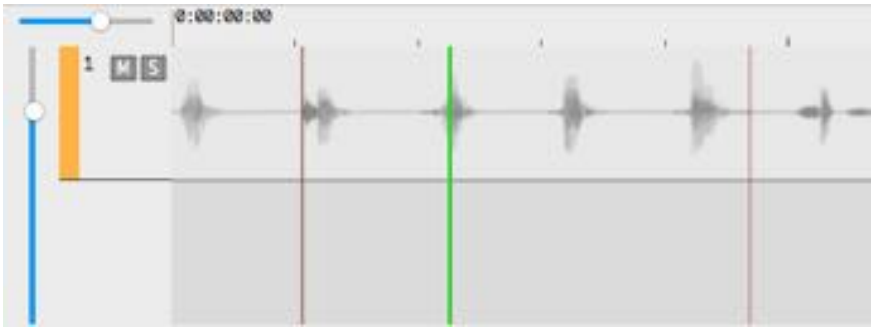


Figure 7.11: The loop start/end time are displayed with thin red vertical lines

Figure 7.12: Using Time Ruler for the navigation

7.4 Creating an Event

Target	Label	Start	End	Type	Len.	Speed	Centroid
ID: 1	Initial Pos	N/A	N/A	I	0	.00	
Marker	Section1	0:00:00:00	0:00:10:00	U	0	.00	
ID: 1		0:00:00:00	0:00:20:00	T	2.34	.12	-.21, -.02

Figure 7.13: Three types of events listed in the event table

As mentioned above, Zirkonium handles three types of events: normal event, initial event, and marker event. You need to follow different steps to create these three different types of events.

7.4.1 Normal Event

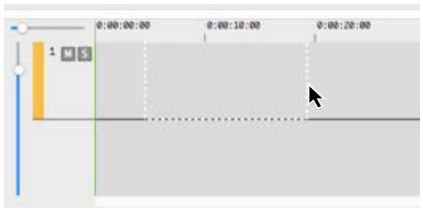


Figure 7.14: Creating an event with the pen tool in the event view

There are two ways to create a normal event that control the movement of an ID or a group. You can create a new event by clicking “+” button in the event tab of the table view, and select an ID or a group as a target, using the pop-up menu in the Target column. Alternatively, you can select the pen tool and draw a region in the event view.

If you make a group event, the “shadow” region(s) appear in the track of the member IDs of the group. These shadow regions indicate that the movement of IDs are controlled by a group event. For example, in figure 7.15, ID 1 and 3 are the member IDs of a group “Alpha”. Thus, the shadow regions appear in the tracks of ID 1 and 3 above the group event.

You are unable to create an ID event that overlaps shadow regions(i.e. group events).

7.4.2 Initial Event

As described in chapter 5, an initial event is created for each ID. This initial event is not manually removable from the event table and a sound path cannot be assignable to an initial event. You can only determine a fixed initial position of an ID, using this event.
Initial events are automatically deleted, when the corresponding IDs are deleted.

7.4.3 Marker Event

In order to create a marker event, select the “event” tab in table view and click the “+” button. Then, an event with “no target” appears in the event table. Change the target to “Marker” with the pop-up menu under the column, “target”. You can provide the newly created marker with a name and a start time.

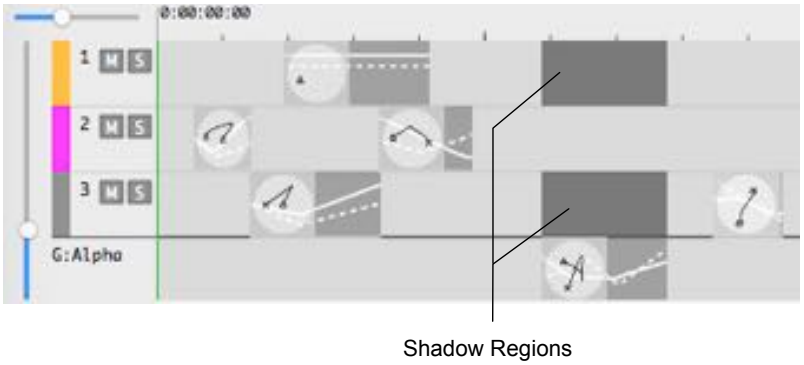


Figure 7.15: Shadow Regions

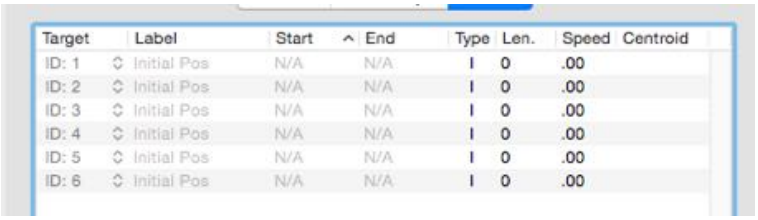


Figure 7.16: Initial Events for each ID

Alternatively, in the event view, you can click the time ruler with the option key pressed. Then, Zirkonium creates a marker event automatically at the clicked position, and name it “newMarker”. The name is modifiable in the event table.

Note, you are unable to draw any sound paths or motion paths for marker events.

7.4.4 Auto Event Creation

To create events for each sound in sound files is a tedious work. Zirkonium offers a way to create events automatically based on the amplitude envelope of the loaded audio data.

To use this functionality, load at least one sound file to the source table, create at least one ID in the ID table, and select **(Edit -> Auto-Event Creation)** from the menu, then the Auto Event Creation Sheet will appear on the window (Fig. 7.19).

The Auto Event Creation(AEC) algorithm checks the amplitude envelope of the target file by calculating the RMS(Root Means Square) of audio sample blocks. If the algorithm find a block, whose RMS value exceeds the provided threshold, the algorithm creates a new event. Then, it attempts to find the end of event by find successive blocks whose RMS are continuously below the threshold.

The sheet consist of the following components:

Source Selector Pop-up Button

The target source file that the AEC algorithm will analyze. The small pop-up button next the pop-up is the channel selector.

Figure 7.17: Marker Events can be added directly

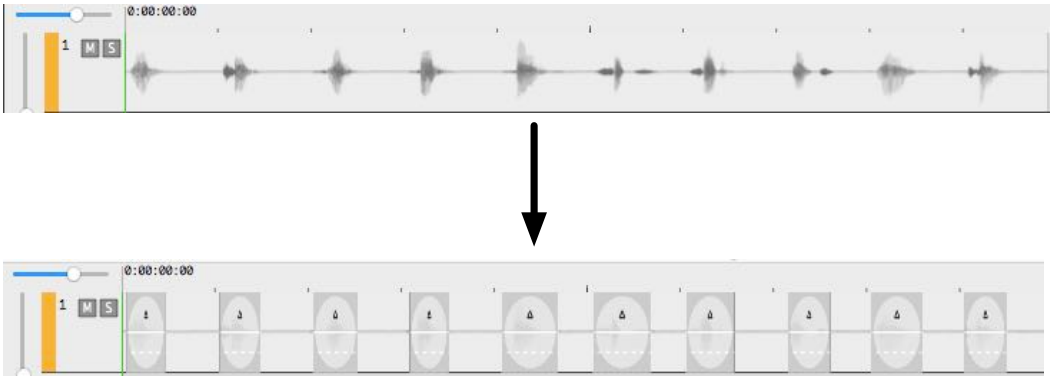


Figure 7.18: Events automatically created by Auto Event Creation

Figure 7.19: Auto Event Creation Sheet

Destination Pop-up Button

The destination ID or group that the automatically created events will be placed.

R The destination of the analysis is not limited to its source. It means, you can easily creates a spatial interaction between two sound sources. For example, when one sound source rings, the other sound source moves. Furthermore, you can select sound source that is not assigned to an ID. Therefore, you can create a series of events based on the audio data, that the audience will never listen to.

Range fields

The algorithm checks the amplitude envelope only the time range defined by "from" and "to" text fields.

You can specify the time range by selecting a marker from the popup buttons or click "loop time" button to apply the loop time defined in the main window.

Analysis Parameters

Block Size This Popup determine the number of samples for RMS analysis. For the percussive sound, small block size tends to produce better result.

Threshold The threshold parameter for the algorithm in decibel. The default threshold is -50 dB. For the recording with recognizable background noise, set the higher threshold.

Hold The algorithm may determine the end of event based on silence in the sound file. However, for example, a phrase played by a percussion instrument may contain a large number of short silence between each attack. In this case, the algorithm may yield a large number of events. In order to avoid this, set the hold parameter high. The hold value sets the duration of silence that the algorithm requires to determine the end of the event. In figure 7.20 shows the difference of created events resulted from the hold parameter.

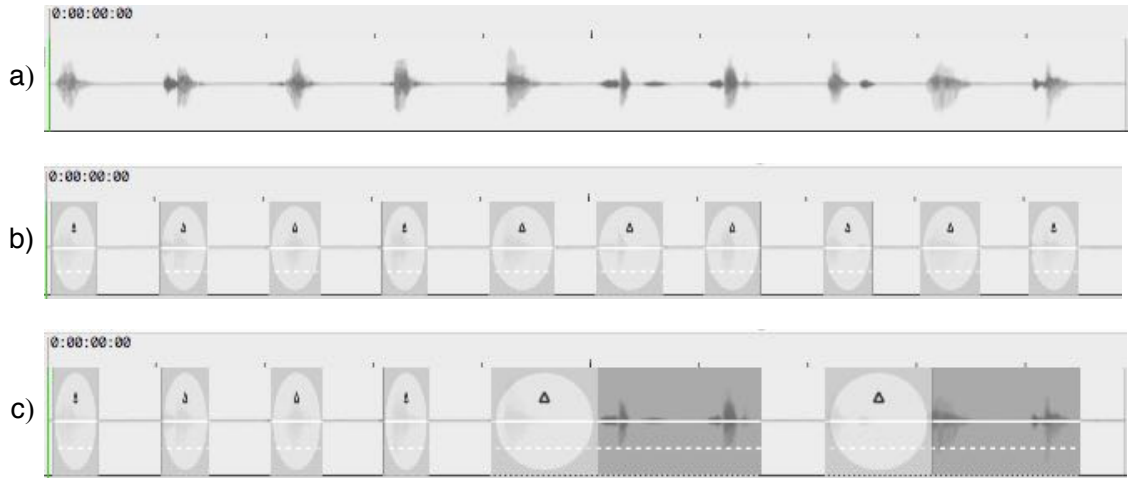


Figure 7.20: Different hold parameters and their results a) sample b) hold = 0.1 secs. c) hold = 0.5 secs.

7.5 Editing Time-related Event Properties

You can edit the time-related properties, such as start time or end time in three different interfaces: Event View, Event Table, and Quick Event Manipulator. Zirkonium provides also event selection panel, which facilitates to select multiple events at once.

R Unlike most of the DAW software, Zirkonium strictly forbids to overlap multiple events. If you try to create or move event on top of another event, the software alerts you and automatically reverts the modified properties of the event(s).

7.5.1 Event View

Shifting Events

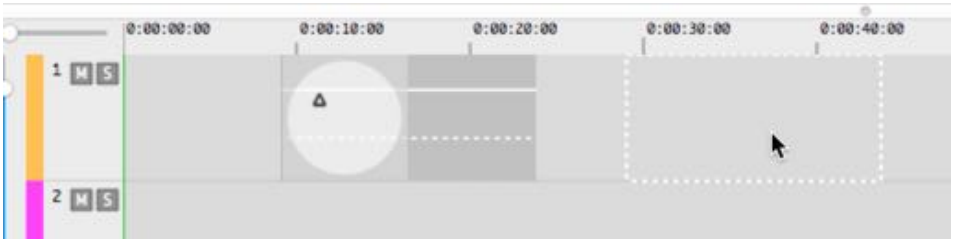


Figure 7.21: Shift Event

In the event view, you can move the event region by simply dragging the region, using arrow tool.

Scaling Events

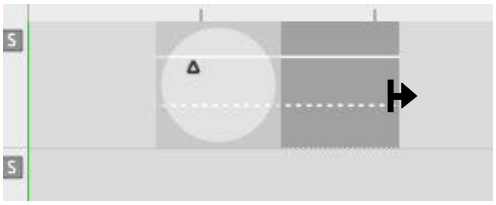


Figure 7.22: Scale Cursor

The arrow cursor becomes the scale cursor, if you hover your mouse cursor over the left or right edge of an event region. This indicates that the region is scalable when you click and drag the edge.

Copying Events

To copy events, press option key and drag the target region(s). It is also possible to shift, scale or copy multiple events simultaneously. Simply select multiple events with shift + click before you perform shift, scale or copy operations. The operation will be canceled, if one of the modified events overlaps with other unselected events.

7.5.2 Event Table

You can edit the start time and end time of events directly in the event table under the Start and End column by double clicking the cells. The provided time should be positive and conformed to *h:mm:ss:ms* format. If you set the end time later than the piece duration, the piece duration will be automatically updated.

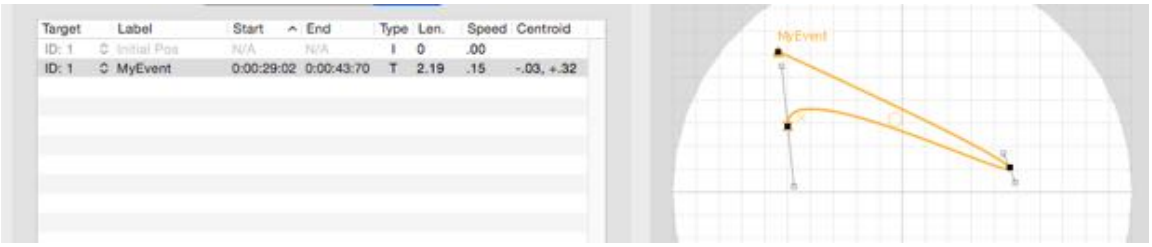


Figure 7.23: Event Name displayed in the dome view

Currently you can name events only in the event table. If you give an event a name, the name will be appeared in the dome view near to the triangle symbol (fig:7.23).

7.5.3 Quick Manipulator

Beneath the table view, there is a set of pop-up buttons and text fields. This is called **Quick Event Manipulator**. You can shift, scale, or copy multiple selected events precisely with them.

The Quick Manipulator offers three different modes. You can select these three modes with the leftmost pop-up button.

Shift mode

In shift mode, you can shift the start time and/or end time of the selected events. With the shift target pop-up button, you can select the target of the shift operation from start time, end time or both start and end time. Enter the direction of the operation by direction pop-up, input the amount of shift time in the shift time field and press apply to execute the operation.

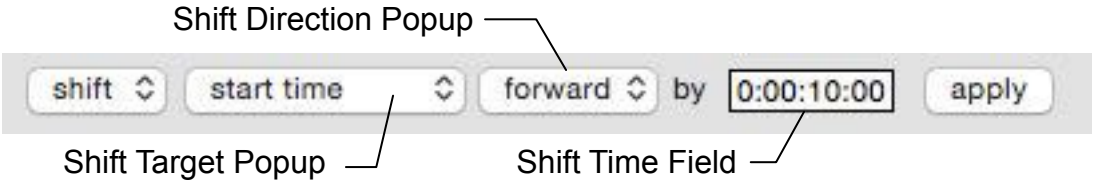


Figure 7.24: Shift Mode

Scale mode

In scale mode, you can scale the duration of selected events. To perform the operation, simply select the direction of scaling, input scale factor with percent and press apply button.

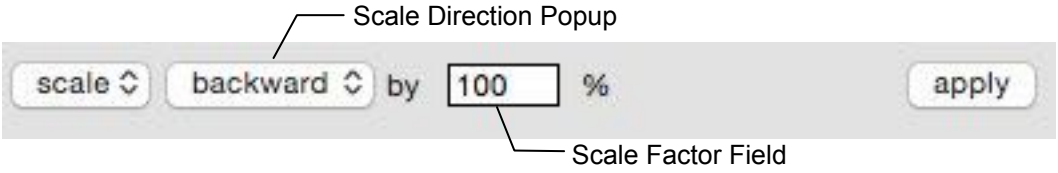


Figure 7.25: Scale Mode

Copy mode

In Copy mode, you can copy the selected events to the specified time. Simply enter the target time in the text field and press apply.

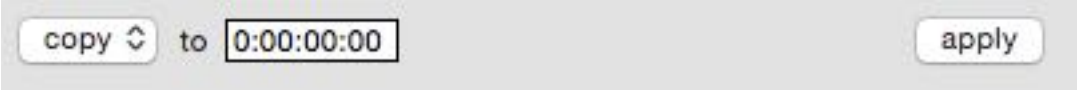


Figure 7.26: Copy Mode

7.5.4 Event Selection Sheet

Your project may consist of a large number of spatial events, and it may sometimes cumbersome to select multiple events you want to modify in event view or event table.

Zirkonium offers a functionality that helps you to select specific events that match certain condition(s). In order to activate this functionality, select "Select Events..." from the edit menu. Then, the **Event Selection Sheet** will appear on top of the main window (fig7.27).

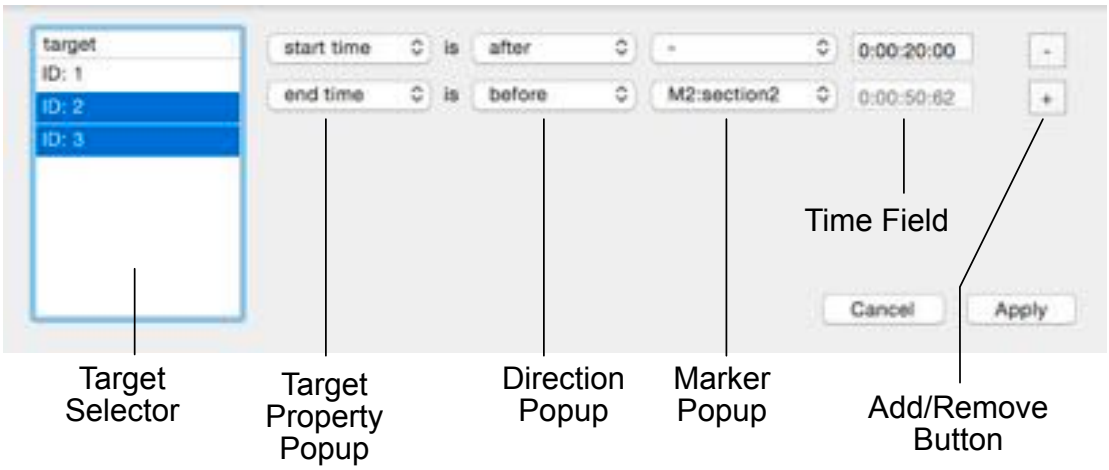


Figure 7.27: Event Selection Sheet

Target Selector

Select target IDs or groups for filtering with this selector. You can select multiple targets by shift + click.

Target Property Pop-up

Select target property from "start time" and "end time".

Direction Pop-up

Select direction of filtering from "before", "after", and "equals to".

Marker Pop-up - Time Field

Enter a time for filtering in *h:mm:ss:ms* format in the time field. Alternatively, select a marker event, using marker pop-up button. If you select a marker with the pop-up button, the time field will be automatically filled with the start time of selected marker and become uneditable.

Add/Remove Button

Press these buttons to add or remove condition.

If all parameters for the filtering are set, press "Apply" button to execute filtering. The sheet will be closed and all events that match the provided conditions will be automatically selected in

the event table and event view.

7.6 Editing Space-Related Event Properties

With **Dome View** and **Motion View**, you can manipulate space-related properties of events, that determine the actual position of IDs at a certain moment. In Dome view, you can draw a sound path, a path that an ID moves along. By default, an ID moves from one end to the other end of the sound path (from the triangle to the cross symbol) in a constant speed. However, you can accelerate or decelerate the movement of an ID, using Motion View.

7.6.1 Dome View

Creating a Sound Path

In Zirkonium, there are two ways to create a sound path. You can either create it with a pen tool and draw a path manually using Bézier curves, or let the software draw curves for you, employing a drawing algorithm.

-Using Pen Tool

Select single spatial event and click the pen tool at the top right corner of the window. Then, click in the dome view. The first click creates the start position of the sound path. The second click creates a tentative end position of the sound path. These two positions are marked with “triangle” and “cross” symbols respectively (fig:7.28).

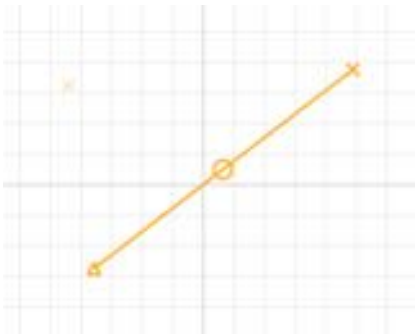


Figure 7.28: Triangle and Cross symbols

If you add more points to the path by clicking the dome view, the path will be extended and the end position of path moves to the newest point added.

To bend a sound path, you can drag the mouse cursor right after adding a point to the dome view. Alternatively, you can select the arrow tool and drag the Bézier handles.

-Using “Create circle / spiral” popover

It’s not easy to draw a perfect circle or spiral with Bézier curves, but Zirkonium offers a utility function that facilitates the creation of a circle- and spiral-shaped sound path.

To activate this function, press right mouse button or Ctrl + left mouse button in the dome view, then “add circle/spiral” context menu should be appeared. Simply click the “add circle/sprial” menu to open **add circle / spiral popover**.

In the popover, input following four parameters that determine the property of a circle / spiral and press add button.

Figure 7.29: add circle/spiral popover

Azimuth from	the origin of azimuth
Azimuth rotate	the amount of azimuth rotation.
Elevation from	the origin of elevation. 90 means that the ID is located at the zenith.
Elevation	The amount of elevation in this event.

Table 7.6: Parameters of Add Circle / Spiral Popover

Editing a Sound Path

-Moving Anchor Points

To move an anchor point, select **arrow tool** and drag the anchor point you want to move.

> You can snap your anchor point to speakers or the grid by enabling "snap to speakers..." or "snap to grid..." options under View -> Dome View menu.

-Bending a Sound Path

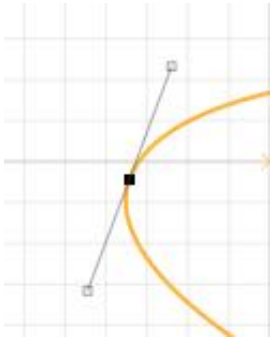


Figure 7.30: Bezier Handles

To bend existing Bézier curves, select arrow tool and drag the Bézier handles (fig:7.30), that stems from an anchor point. Two handles belong to one anchor point and each of them controls different side of the curve. By default, these two handles are moved together, when you drag one of them, but you can move single handle by pressing shift and dragging. To reset a curve, click the handle with the option key pressed.

-Applying Affine Transformation to a Sound Path

With affine tool, you can translate, rotate, or scale the entire sound path drawn in the dome view. In order to apply these operations, select the affine tool beneath the pen tool. Then, a bounding box with 9 small black handles, called **affine handles**, appears around the path.

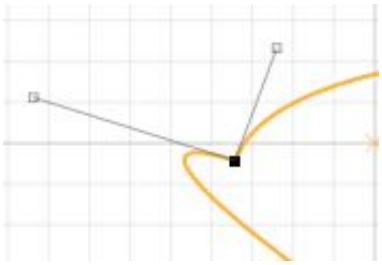


Figure 7.31: Bending one side by shift + drag

To translate the path, drag the handle in the middle. To rotate the path, drag the line of the bounding box. To scale the path, drag the 8 black affine handles surrounding the path.

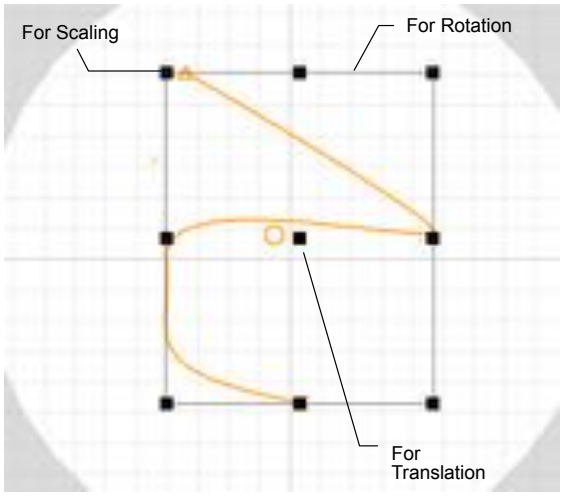


Figure 7.32: Affine Handles and their functions

-Snapping start or end position of a Sound Path

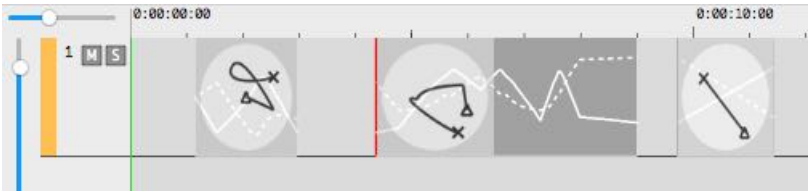


Figure 7.33: Incontinuity of sound paths

While playback, an ID instantly jumps to the start position of the sound path without any interpolation, when the playback cursor reaches the start time of a certain event, unless the end position of the previous event perfectly matches the start position of the current event. This abrupt change of ID position or "jump" at the beginning of an event may cause unnatural audio incontinuity, especially an audible signal is fed to spatial rendering algorithm at the moment of the "jump". Zirkonium automatically finds these "jumps" and indicates them with red lines (called Jump Warning Line) at the left edge of event regions (fig7.33).

There are four solutions to avoid this problem.

1. moving the start position of the current event to the end position of the previous event
2. moving the end position of the previous event to the start position of the current event

3. creating one more event between the current and previous event for interpolating the start position of the current event and the end position of the previous event
4. starting the event at the moment when the source (sound file or live input) produces absolutely no sound

Zirkonium is capable of performing above-mentioned solutions 1 - 3 automatically. To move the start position of the current event to the end position of the previous event, press “snap to cross” button (fig:7.34) above the camera position reset button.

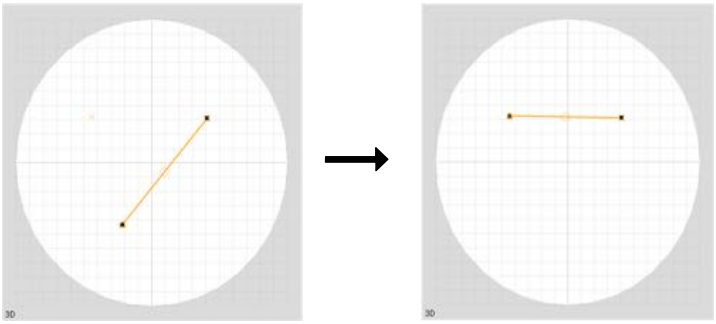


Figure 7.34: Snap To Cross

To move the end position of the previous event to the start position of the current event. Select the previous event in the event table or event view and press “snap to triangle” button (fig:7.35).

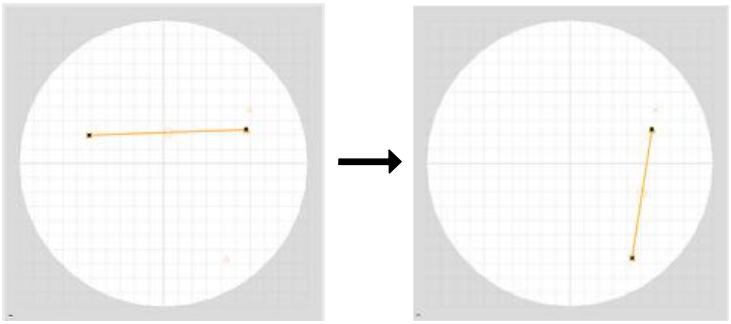


Figure 7.35: Snap To Triangle

To create an interpolation event, simply create an event between the current and the previous event with the pen tool. The newly created event will be automatically filled with a sound path, that interpolates the start position of the current event and the end position of the previous event (fig:7.36).

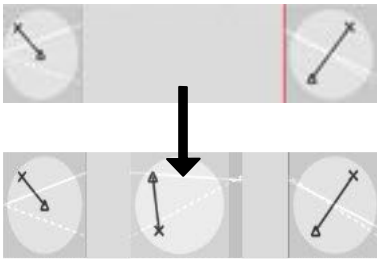


Figure 7.36: Interpolation Event

-Moving Camera Position

You can move the camera position vertically by rotating your mouse wheel and horizontally by shift key + mouse wheel. Zooming in/out is also possible by command key + mouse wheel. To reset the camera position, click the Camera Position Reset Button above the sliders.

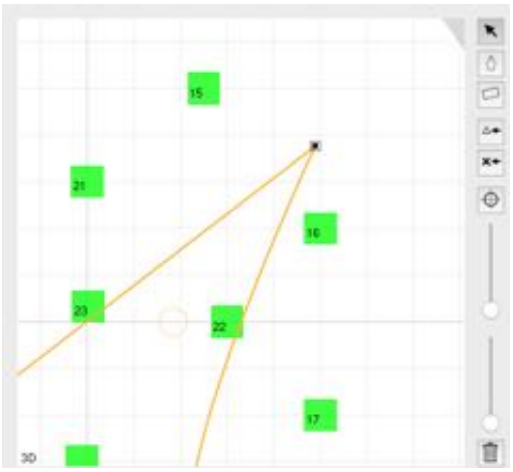


Figure 7.37: Zoomed Dome View with shifted camera position

-Deleting a part of a sound Path

To delete specific parts of a sound path:

1. Click on the dome view and drag the mouse. A selection rectangle should be appeared on the view.
2. When the mouse button is released, all anchor points within the selection rectangle turn red. It means these anchor points are selected.
3. Press delete key to delete the selected anchor points. Click an empty space in the dome view to deselect all selected anchor points.

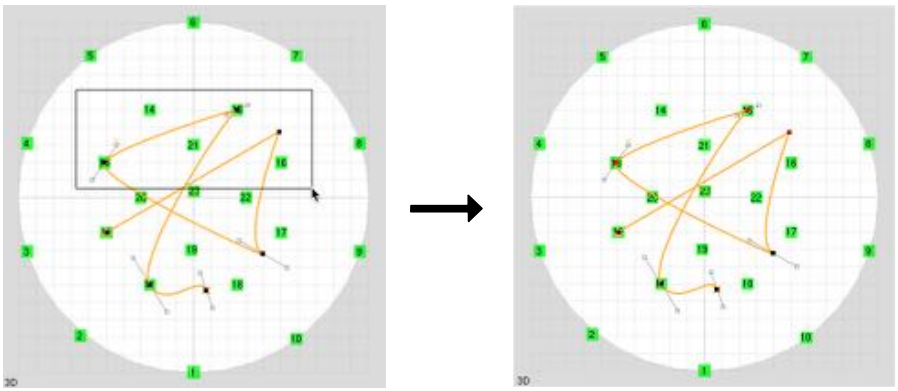


Figure 7.38: Selecting certain anchor points

-Deleting entire sound path

To delete a sound path in the dome view, simply click on the “trash” button located near to the right bottom corner of the dome view.

7.6.2 Motion View

You can control the movement of ID along the defined sound path and expansion of sound diffusion with motion view. A motion path and a span path are automatically created, when an event is created. The motion path becomes editable when more than one anchor points are added to the dome view. In other words, motion path is not available for an instantaneous event with single anchor point or undefined event with no anchor point.

Switching motion mode and span mode

By clicking **motion / span switch** located at the right of the motion view, you can change the current mode of the view (fig7.39).

Figure 7.39: In Motion Mode (Left) / In Span Mode (Right)

Editing motion path

Motion path defines the position of an ID along the sound path during the time frame of an event. By default, the ID moves from the start position (triangle symbol) to the end position (cross symbol) in a constant speed. However, you can bend the path and add extra anchor points to the path for realizing more complex movement of ID between the start and end position.

-Bending curves

To bend the motion path, hover the mouse cursor on the motion path with the arrow tool and make the cursor an open-hand. Then, click the curve and drag it up and down to bend.

Figure 7.40: Bending Motion Path

-Adding anchor points

The position of two anchor points provided by default can not be moved, since an ID has to move from the start position (triangle) to the end position (cross). However, you can add extra anchor points in the motion view by clicking the view with the pen tool (fig:7.41).

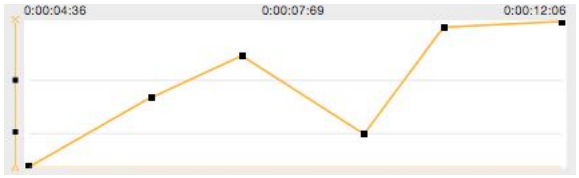


Figure 7.41: A Motion Path with multiple anchor points

-Adjusting the position of audio content to be played

By combining the dome view and motion view, you can adjust the position of audio content without changing the shape of sound path. here is an example:

In figure 7.42-left, an one-second sound material is spatialized. In this setting, the loudest part of this audio material will be mainly played by the speaker No. 20, if you do not edit the motion view at all.

In case you want the loudest part of this audio material to be played from speaker No. 21, add one more anchor point and place the anchor point in the middle of the sound path on top of speaker No. 21. The added anchor point is also displayed in the Mini-Sound Path at the left side of the motion view (fig:7.42-center).

Then, add an anchor point also in the motion view and place it at the loudest moment in the waveform and anchor point at the mini-sound path. This means that ID reaches the anchor point on the Mini-Sound path (i.e. speaker No. 21) at the loudest moment (fig:7.42-right).

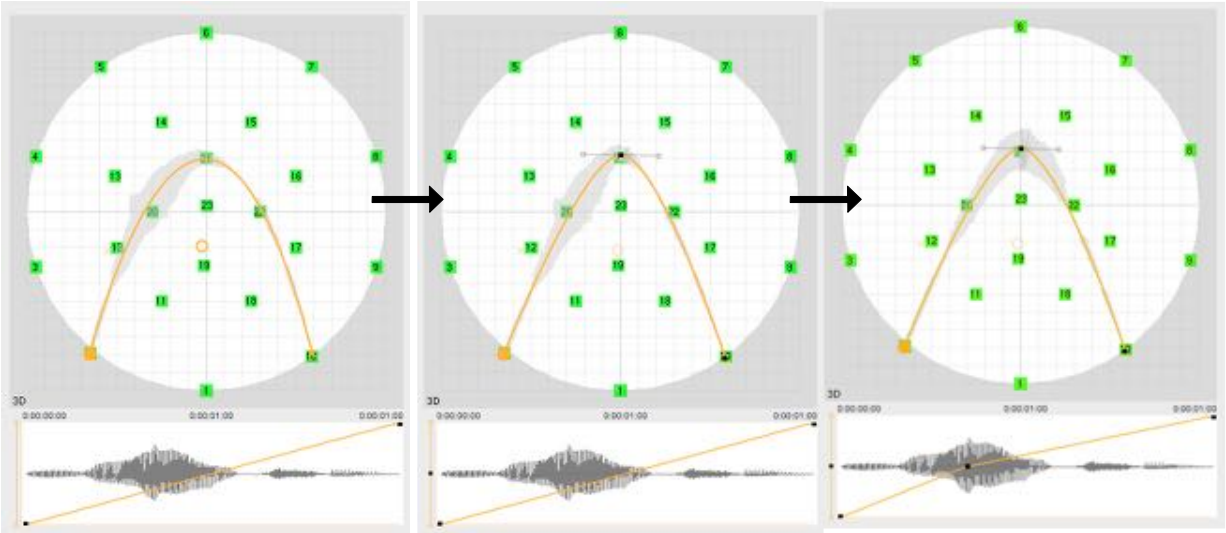


Figure 7.42: Adjusting audio content and position

In this way, you can manipulate the relationship between the position in dome view and the audio content flexibly.

-Deleting a part of a motion/span path

To delete the added anchor points in motion view, select the arrow tool and draw a selection rectangle in the motion view. The selected anchor points in the selection rectangle turn red and should be deleted, if the delete key is pressed (fig7.43).

Figure 7.43: Region Selection in Motion View

You can not delete the first and end anchor points.

Editing span path

The span path can be drawn in the similar manner. However, unlike a motion path, a span path doesn't have to reach the top-right corner of the view at the end time of an event.

Resetting the entire sound / span path

To reset the motion path and the span path at once, simply click on the "trash" button located at the right bottom corner of the motion view.

8. Exporting Projects

In order to improve the compatibility and to realize long-term preservation, Zirkonium offers various exporting functionalities, SpatDIF, Bounce and Archive. This chapter describes each function.

8.1 Exporting SpatDIF

8.1.1 What is SpatDIF

According to the official website (`http://spatdif.org`), the definition of SpatDIF is as follows:

> SpatDIF, the Spatial Sound Description Interchange Format, is an ongoing collaborative effort offering a semantic and syntactic specification for storing and transmitting spatial audio scene description. The SpatDIF core is a lightweight minimal solution providing the most essential set of descriptors for spatial sound scenes. Additional descriptors are introduced as extensions, expanding the namespace and scope with respect to authoring, scene description, rendering, and reproduction of spatial sound.

Zirkonium has capability of exporting trajectory events, using the syntax of SpatDIF. For details of the syntax, refer the website of SpatDIF.

8.1.2 Export as SpatDIF File

To export a SpatDIF-conformed XML file, simply select **File -> Export to SpatDIF** from the menu.

Zirkonium *samples* spatial events every 25 msec and export these sampled trajectory data, using SpatDIF core descriptors. You can load the exported SpatDIF XML files onto Max or Pure Data patches, using SpatDIF external objects, available from ICST Zürich (`https://www.zhdk.ch/index.php?id=icst_spatdifexternal`). You can find a simple demo of SpatDIF export with a Max patch in demo folder of the package.

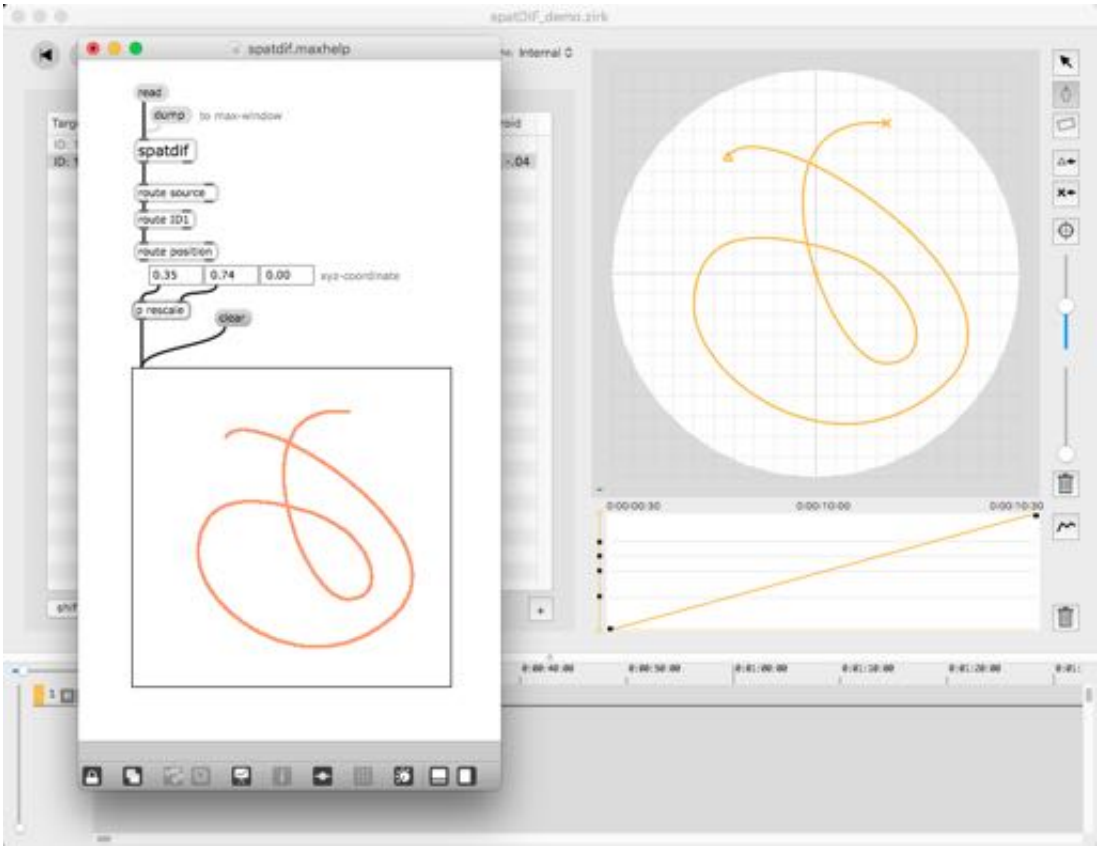


Figure 8.1: A trajectory, designed by Zirkonium, loaded onto a Max Patch

8.2 Bouncing

Bounce function allows you to record all audio signals sent to loudspeakers and store them in sound files.

In order to activate bounce function, select File->Bounce. Then, a save panel will appear. Select the destination folder, name the bounced file, and click "Save" button. Then, the modal sheet "bouncing in progress" will appear on the window (Fig. 8.2).

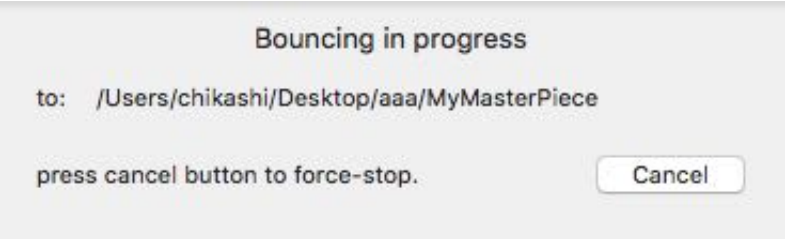


Figure 8.2: Bouncing in progress modal sheet

Note, the bounce function **does not** create a new folder automatically for the bounced files and the bounced files are automatically suffixed by the speaker index number(Fig. 8.3).

The bounce function is currently "online"; bouncing requires the duration of the piece. To interrupt bounce, press "cancel" button.

R The format of the bounced sound files is WAV 24 bit.

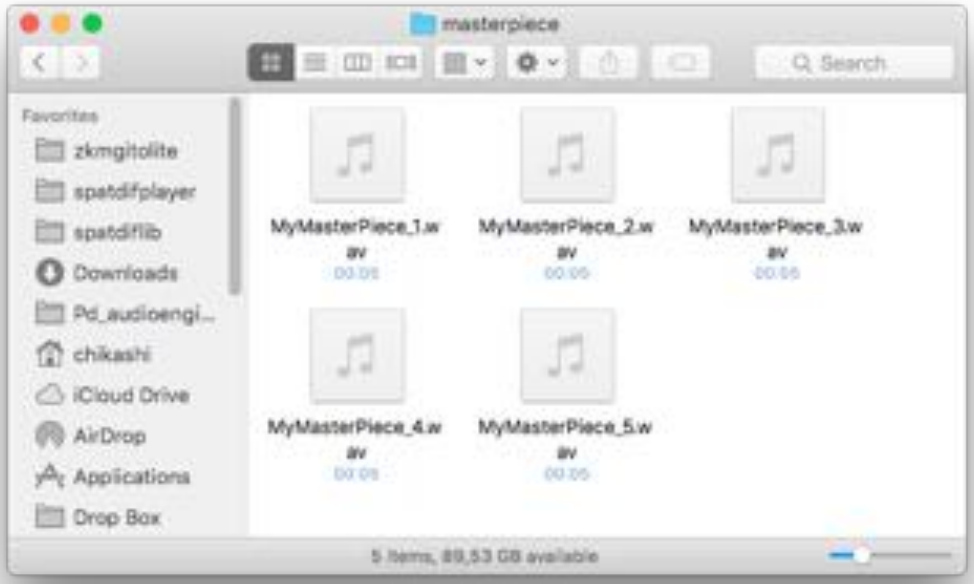


Figure 8.3: Bounced files are automatically suffixed

8.3 Archiving

You can import multiple sound files located at different folders on your disk system. Zirkonium stores their absolute paths and reload the data again when the Zirkonium document is reopened. However, in case you want to copy your piece to another computer or email your piece to somebody else, you may need to gather all your sound files scattered in your disk system and make a package that contains all data required for reconstruct your piece in another environment (This process is often called "consolidation"). Zirkonium offers a function to automatically execute this process. Save your current project at least once and select **File->Archive Project**.

Then Zirkonium creates a new folder under the folder where the Zirkonium file is located and name it *project name*_archive. Then, all sound files used in the project as well as the Zirkonium file itself are stored in this folder. The zirkonium file is automatically suffixed with "_archive."

You can compress the created folder and copy it to for example another machine or disk system.

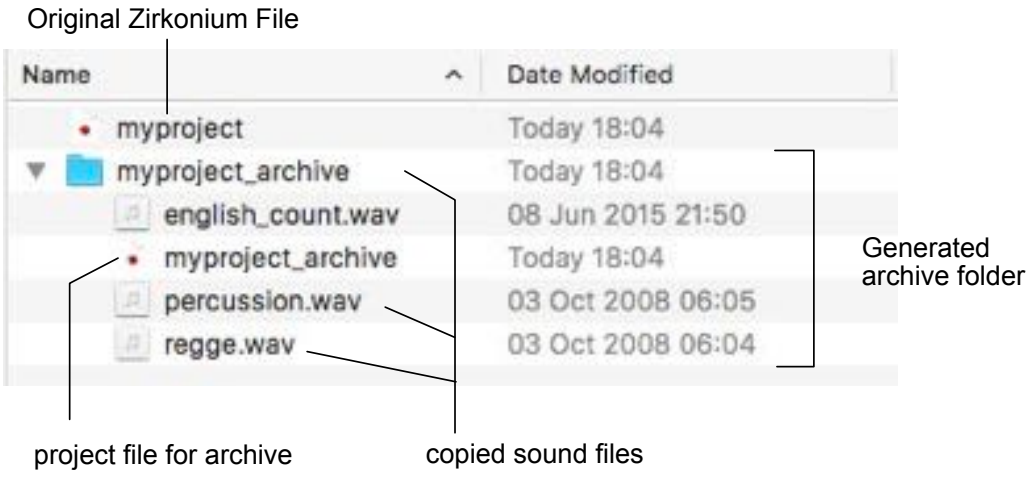


Figure 8.4: An example of archived project

9. Other functionalities

This chapter briefly introduces further functionalities of Zirkonium Trajectory Editor.

9.1 Importing MK1

To import Zirkonium file created with "classic Zirkonium", select **File->Import MK1 File**. It imports all ID and groups properties as well as their events.

9.2 Controlling with OSC

The position and span of each ID can be controlled by another applications, such as Max, Pd, SuperCollider via OSC message. All configuration in regard with OSC message traffic can be configured in the “Network Settings sheet”. This sheet is accessible from File > Network Settings menu 9.1.

The left side of the sheet configures the internal OSC senders in the Trajectory editor that send spepcific data in realtime to external software and hardware. The right side of the sheet configures the internal OSC receiver that receives OSC messages from external software. You can have multiple senders within the Trajectory editor but only one receiver.

9.2.1 OSC Sender

The left side of the sheet configures the internal OSC senders.

OSC Sender table

The table shows currently active OSC senders. You can configure following parameters for each sender

IP address The IP address of the device that the sender send messsages to
port The port of the device that the sender send messages to
Time if checked, the time message will be sent
IDPos if checked, the position of each ID will be sent

Figure 9.1: Network Setting Sheet

IDSpn if checked, the span of each ID will be sent
IDLev if checked, the current level of each ID will be sent
QT if checked, messages for ZirkQTplayer will be sent
IP address and port fields become editable by double-clicking.

Add Sender fields

You can add new senders by entering IP and Port in the add sender fields and clicking the "+" button.

Address Patterns

This four field determine the OSC address pattern of the ID position, ID span and time messages. @{id} in the address pattern will be replaced with the ID number when a message is sent.

Initialize button

One this button is clicked, the Trajectory editor sends the ZirkPad initialization message, containing definitions of all IDs and groups to all devices listed in the OSC sender table.

9.2.2 OSC Receiver

The right side of the sheet configures the internal OSC receiver.
"allow control with OSC messages" check box when this check box is checked, the Trajectory editor accepts incoming OSC messages
Port The OSC port used for receiving OSC messages
OSC Address Patterns the list of OSC messages that the Trajectory editor currently accepts

9.3 ZirkOSC3

ZirkOSC3 (Fig. 9.2) is an AU/VST plugin developed by Robert Normandaue for controlling Zirkonium remotely from a DAW software via OSC protocol.

9.3.1 Download and Installation

ZirkOSC3 is available under `https://sourceforge.net/projects/zirkosc3/`. Uncompress the package and place VST and AU-component under /Library/Audio/Plug-Ins/VST or Compo-

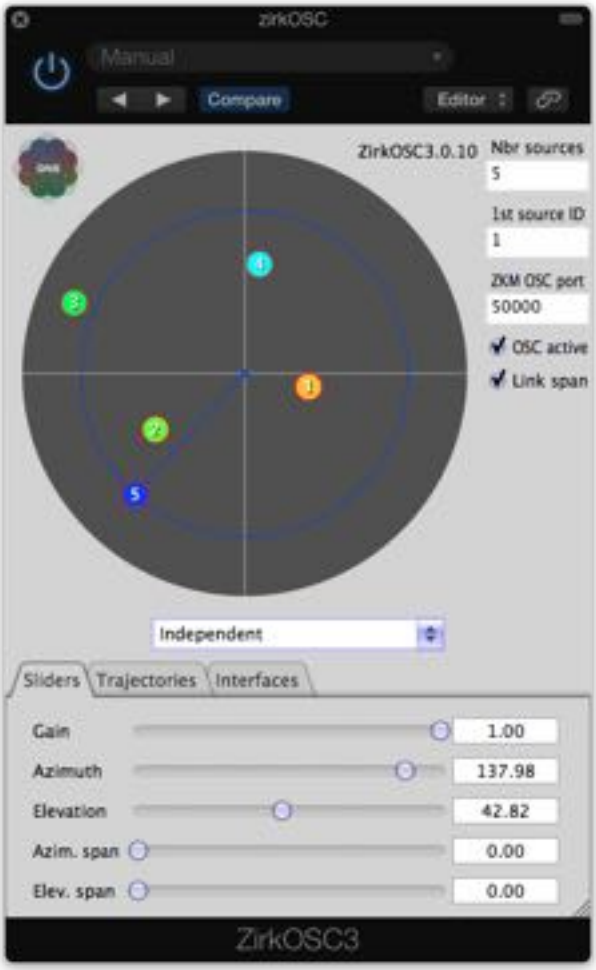


Figure 9.2: ZirkOSC running on Logic Pro

nents.

9.3.2 Network Setting

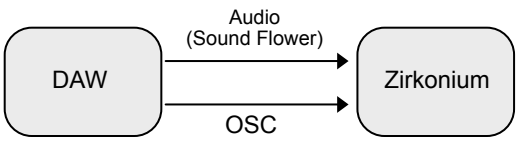


Figure 9.3: DAW-based spatialization system, using Zirkonium as a renderer

In order to receive OSC messages from ZirkOSC, the OSC receiver must be activated. Open the Network Setting (**File -> Network Settings**) and check if the OSC receiver is activated.

R Most composers combine ZirkOSC and "audio piping" software such as SoundFlower, in order to send not only OSC messages but also audio streams from the DAW. In this way, the user is able to utilize Zrikonium Trajectory editor solely as a spatialization engine or a "renderer" of DAW software (Fig. **??**).

9.4 Syncing with other software

Zirkonium is able to synchronize with other Audio software, such as Logic, Ableton Live or Max, using MIDI Time Code or OSC. You can select a mode for synchoronization with a pop-up button beneath the Transport bar.

Figure 9.4: Sync mode pop-up button beneath the Transport Bar

The followings are the descriptions of each mode.

internal

Trajectory Editor doesn't send or receive any messages for sync.

MTC Master

Sends MTC message to a MIDI endpoint during playback.

MTC Slave

Accepts MTC message from other software and adjust current time to the received messages. If this mode is selected, play button will be immediately disabled and become unclickable.

> MTC Frame Rate that Zirkonium sends in MTC Master mode is fixed to 30 fps and currently not modifiable.

> In MTC Master Mode, Zirkonium sends **Full Frame MTC Messages** when the user manually inputs a new time to the current time field or click on the time view. Zirkonium sends **Quarter Frame MTC Messages** during the playback.

9.5 Customizing Spatialization Server

R This section is intended for advanced Pd users. If you are not familiar with Pd and would like to modify/customize sptialization algorithms of Zirkonium. Please refer the Pd website `http://puredata.info`.

9.5.1 How Zirkonium realizes spatial rendering

Zirkonium internally utilizes Pure Data as a audio processing engine, and this core functionality is integrated in the Zirkonium Trajectory Editor, employing libPd.

You are able to access the **Zirkonium Spatialization Server**, a Pd patches that processes the sound files and executes spatialization algorithms, and customize it AT YOUR OWN RISK.

9.5.2 Accessing Zirkonium Server Patch

In order to access the Zirkonium Server Patch, right click on the ZirkoniumTrajectoryServer application icon and choose "show package content"[Fig:9.5]. You will find the core Pd patch named "zirkonium_server.pd" as well as a few abstractions and external objects under Contents/Resources folder.

nc

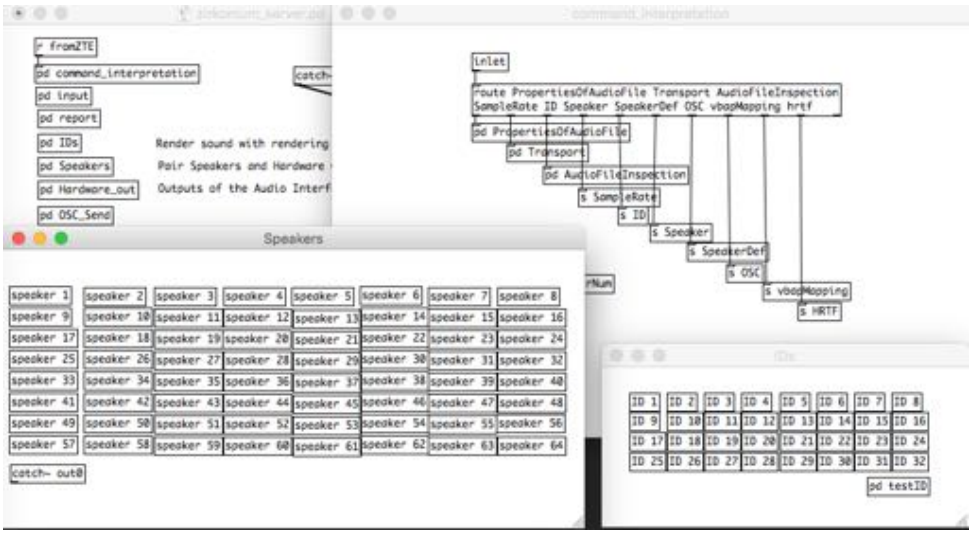


Figure 9.5: Location of Zirkonium Server

10. Appendix 1:ZirkPad

10.1 What is ZirkPad?

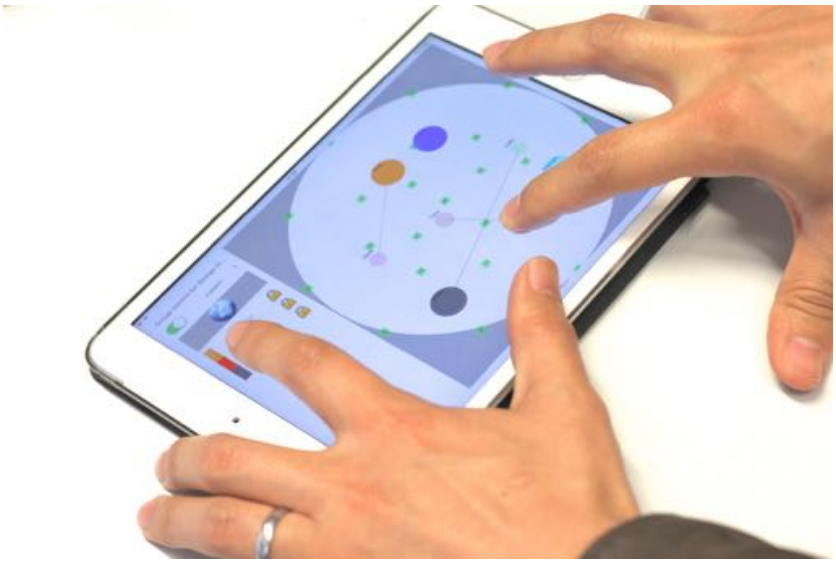


Figure 10.1: Live spatialization with ZirkPad

ZirkPad is an iPad App that enables users to control the position and the span of each ID and group of the Zirkonium Trajectory editor with the multi-touch interface remotely. This app is developed for mainly following three sinarios.

Live Diffusion of more than two channels

With ZirkPad, you can spatialize upto 64 channels of sound sources and control the movement of each sound source directly by dragging the virual sound object displayed on the multi-touch-screen. In this way, ZirkPad offers an alternative live-spatialization strategy in contrast to the traditional "diffusion", a live expansion of stereo fixed-media using a mixing console and multiple stereo-pairs

of speakers arranged in a listening space.

Sound reinforcement for a surround speaker system

Zirkonium trjaectory editor is capable of patching live inputs and IDs. Thus, ZirkPad can be used for live performance with musicians. ZirkPad assists PA-engineer to "place" the audio signals coming from each instrument onto a surround loudspeaker system.

Listening and controlling at various position

Sound impression varies significantly depending on the position of the listener and all concert guest can not listen the sound from the sweetspot. Thus, we are often required to listen and evaluate how the sound source is heard at the various positions of the listening space. Beacuse ZirkPad runs on an iPad and send message wirelessly to the Trajectory editor, you are able to walk around the listening space and control the position of sound source at the same time. This significantly reduces the time for audio configuration before a concert.

10.2 System requirement

ZirkPad requires the following hardware/software environment.

10.2.1 Hardware Requirement

All iPad except the first generation iPad.

10.2.2 OS

ZirkPad supports **iOS 9 or higher**.

10.3 Network preparation

An iPad or multiple iPads, running ZirkPad, should be connected to the same local area network (LAN) of the host computer, runing Trajectory editor as shown in figure 10.2.

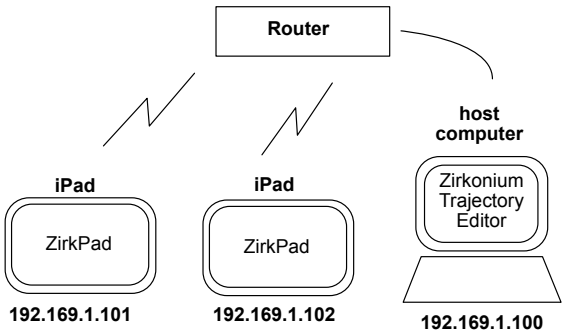


Figure 10.2: ZirkPad Network

R It is highly encourage to use a dedicated router, assign static IP address for each device, and non-crowded WIFI channels for the live performance.

10.4 Installation

You can download and install the application from the App store.

10.5 Initialization

The following information will be sent from the Trajectory editor to the ZirkPad. It is highly encouraged to name all your IDs and groups before sending initialization message from the Trajectory editor to the ZirkPad.

- ID name
- ID color
- ID initial position
- Group name
- Group master
- Speaker positions

10.5.1 OSC sender setting

In order to send OSC messages from the Trajectory editor to ZirkPad, an OSC sender should be defined in the Trajectory editor. To create a new OSC sender in the Trajectory editor, open the Network Settings sheet by selecting File->Network Settings menu.

Figure 10.3: ZirkPad shows the IP address of iPad by default

IP Address	Port	Time	IDPos	IDSpn	IDLev	SpLev	QT
192.168.237.252	50001	☐	☐	☐	☑	☑	☐

Figure 10.4: Typical Setup for ZirkPad

1. Make sure OSC receiver on the right side of the sheet is activated and the port number is set to **50000**.
2. Launch the ZirkPad App on the iPad and check the IP address shown in the gray square on the right side (Fig. 10.3) .
3. Enter the IP address of the iPad in the “add sender” field at the buttom of the OSC sender table.
4. Set the port number to **50001** and press the “+” button
5. A new sender will be created in the table

6. Check the boxes **IDLev** and **SPLev**. By checking these check boxes the Trajectory editor sends the level of each ID and speaker to the ZirkPad. You can also deactivate these two in order to reduce the number of OSC messages.
7. Click the "initialize" button at the bottom of OSC Sender section.

When the initailization is successful, loudspeakers and IDs will appear in the Dome view. If not, you will receive an error message. If you receive an error message, please click the "initialize" button again 10.5.

If you change the configuration of IDs and groups in the Trajectory editor, send initialization message again by pressing the initialize button.

Figure 10.5: Initialization

If ZirkPad doesn't react to the initialization from the Trajectory editor, check the network setting of both device.

10.6 GUI Overview

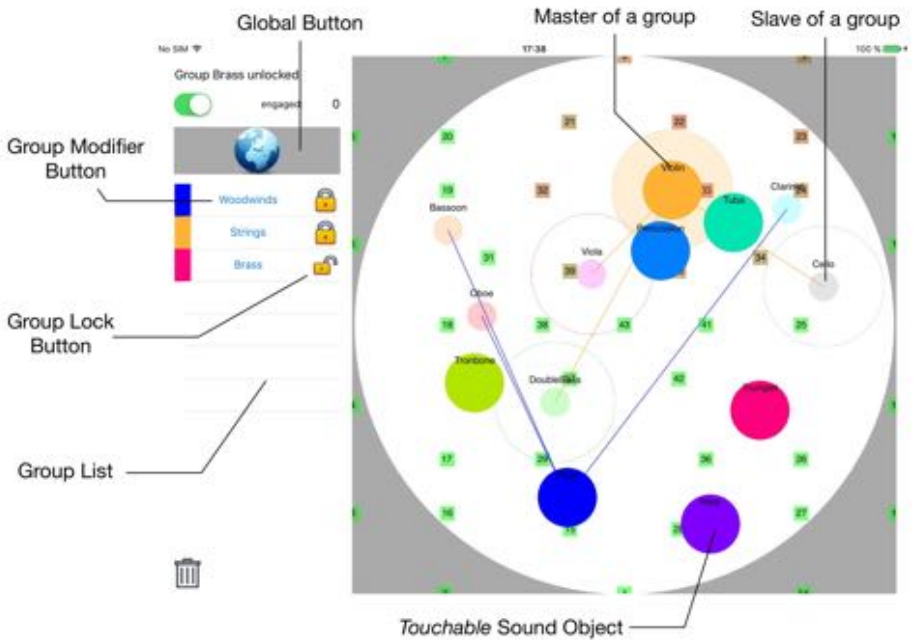


Figure 10.6: Zirk Pad GUI

The figure 10.6 shows the main GUI of the ZirkPad. On the right side of the screen, the multi-touch-enabled Dome view is displayed. It synchronizes with the Dome view of the Trajectory editor and visualizes the position of speakers and sound objects as well as the levels of the audio signals that each sound object generates and each speaker receives.

All IDs are labeled with the their names. The group networks are displayed with thin straight lines. By default, all slaves are visualized with small circles and they are not controllable.

The left side of the window shows several buttons and switch to activate group-based functionalities.

Global Lock Switch

This switch activate/deactive all functionalities that the left pane of the ZirkPad offers. By deactivating the functions in the left pane, you can avoid unintended manipulations caused by touching the left pane.

Global Button

If this button is pressed, all IDs in the dome view will be controlled parametrically (see 10.8.2 for details)

Group Button List

The group list shows the names of ID groups defined in groups table in the Trajectory editor. The colors of the small rectangles next to the group names derive from the color of the Master ID of each group.

Group Modifier Button

When a name of group is pressed, ZirkPad enters “Group mode” and allows you to control the designated group in various ways. For details, refer to section **??**.

Group Lock Button

When the group lock button is activated (locked), you can not control the position of slaves in a group. But once it is unlocked, you can control the position indivisually and change the formation of a group.

10.7 Single ID Manipulation

Unlike the Dome view in the Trajectory editor, the sound objects in the Dome view in ZirkPad are *touchable*; you can move ID objects that do not belong to any groups by dragging them with your fingers. As soon as ZirkPad recognizes touches on sound objects, it sends OSC messages to the Trajectory editor. In response to the received OSC messages, the Trajectory editor updates the position of the sound objects immediately.

In order to control the span (diffusion) of an ID, first press the an ID circle by a finger, place another finger on the dome view, and drag your the finger along Y-axis. Then, a thin circle will appear around the target ID. This circle indicates the current span of the ID.

10.8 Group-based Manipulation

If you want to control multiple IDs at once, ZirkPad offers two options:*Direct mode* and *Parametric mode*.

10.8.1 Direct mode

Your can control the position of each ID just by directly dragging the master ID in the dome view. Slave IDs follow the masters using rotate mode described in the chapter 6. Note, slaves of a group

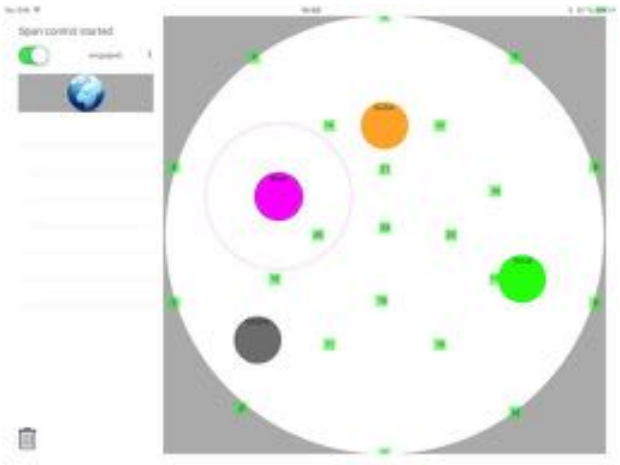


Figure 10.7: The Span circle indicated around an ID

cannot be touched by default because all groups are “locked”. However, you can unlock the group by tapping group lock button next to the group name in the group list. If you move the position of the slaves and lock the group again, the formation of the group will be changed.

10.8.2 Parametric mode

By touching a name of the groups in the group list, you can enter the parametric mode. You can exit this mode by simply releasing your finger from the group list.

In the parametric mode, your finger gestures in the dome view control the position of IDs that belong to the pressed group *relatively*. The movement of the group is determined by the number of fingers you use in the dome view.

One Finger: Diffusion

If you use one finger and drag the dome view along Y-axis, you can rotate all designated IDs.

Two Fingers: Rotation

If you use two fingers and swipe the dome view along Y-axis, you can control only the elevation of all member IDs.

Three fingers: Translation

If you use one finger and drag the dome view, you can translate all members of the tapped group.

By touching the global button above the group list, you can control all existing IDs and groups in the manner of the parameteric mode.

10.9 Multiple manipulator

As the figure 10.2 shows, two or more manipulators can control one Trajecotry Editor simultaneously.

However, if multiple manipulators are allowed to controll all IDs, they may send different commands for an identical ID at the same time, and it may result in abrupt “jump” of the ID position.

In order to avoid it, we can reduce the number of group that one manipulator can access. After the initialization, each manipulator can remove specific groups from the group list by tapping groups and the trash button at the same time. In this way, we can isolate the control of multiple manipultars completely and avoid command conflicts.

11. Appendix 2: Speaker Setup

Speaker Setup is a Mac OSX Software, that enables you to set up your own non-standardized loudspeaker configurations. The application let you graphically organize the speakers and export the configuration as a XML file. The exported XML can be loaded onto the dome view of Zirkonium.

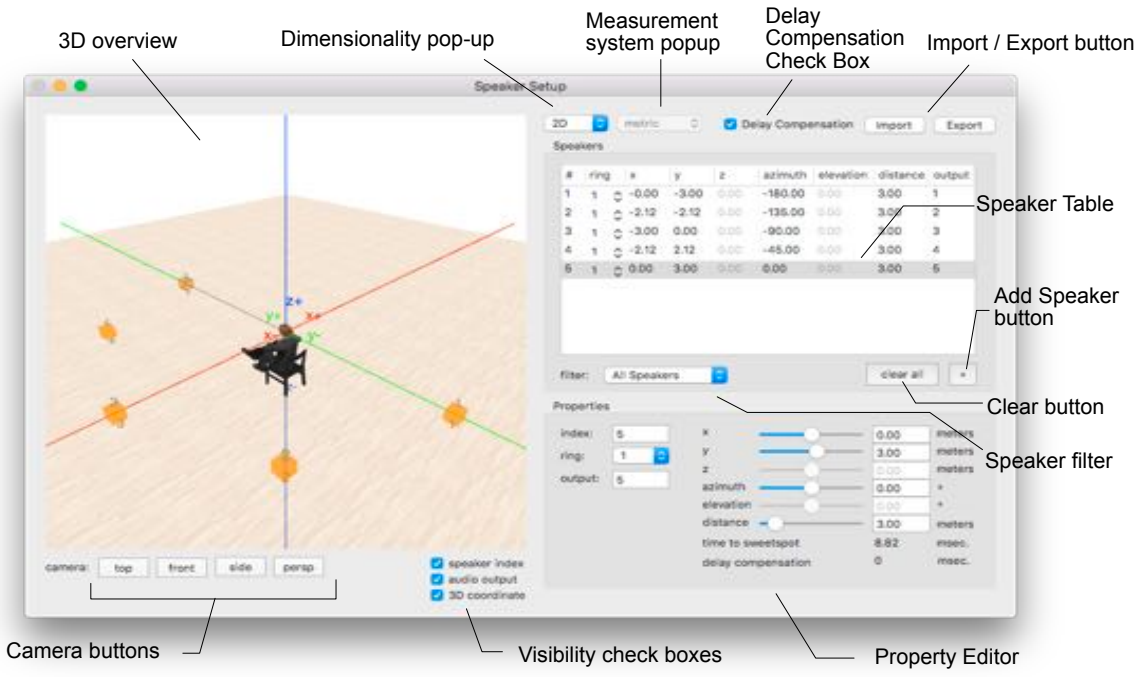


Figure 11.1: Speaker Setup

11.1 Installation, System Requirements

For the installation, just copy the Speaker Setup to your Applications folder. The application runs on Mac OS 10.9 or later.

11.2 GUI Overview

11.2.1 3D overview

This view shows a listener, surrounded by speakers, in a 3D space. You can change the camera position by dragging the view and zooming in/out by rotating the mouse wheel.

In the view, each speaker is indicated as a cubic object with a color. The furthest speakers from the sweet-spot is indicated with a thicker color than the other speaker. This speaker is used as the reference speaker for calculating the delay compensation.

The black numbers above the speakers indicate the index number of each speaker, and the brown numbers below the speakers are the numbers of the associated audio hardware outputs.

11.2.2 Camera buttons

By these buttons, you can move the camera in the 3D overview instantly to a specific position.

11.2.3 Dimensionality pop-up

You can define the dimensionality of your speaker setup. 2D means all speakers are positioned at the same height (ear level). If you select 2D, the z and elevation values of all speakers are instantly set to 0 and become uneditable.

11.2.4 Measurement system pop-up

In the speaker setup, you can define the position of speakers either with metric values or relative values from -1 to 1. This pop-up allows you to select a mode from these two options. This pop-up button will be disabled, when you add the first speaker to the view. To enable this pop-up button again, delete the all speaker in the view.

R In case you select the relative mode, Speaker Setup will not output XML attributes for delay compensation.

11.2.5 Delay Compensation Check Box

This check box enable or disable the calculation of delay compensation, based on metric distances between

11.2.6 Import / Export button

These buttons let you export and import XML data that contains single loudspeaker configuration.

11.2.7 Speaker table

This table lists all or filtered speakers in the 3D overview. if you select a speaker in the list, the black line appears in the 3D overview for indicating selected speaker.

You can delete the speaker by selecting a speaker and pressing the delete key.

The following is description of each column of the table

#

Index number of each speaker. The number must be unique.

ring
The ring (i.e. speaker group) that the speaker belongs to. You can choose it from ring 1 to 10.

x,y,z
The position of speaker in Cartesian coordinate. when you change one of these values, the value of azimuth, elevation, and distance will be automatically recalculated.

azimuth, elevation, distance
The position of speaker in spherical coordinate. When you change one of these values, the value of x, y, and z will be automatically recalculated.

Output
The audio hardware output channel assigned to the speaker.

11.2.8 Speaker filter
With this pop-up button, you can filter speakers shown in the table by the index number of rings. This function is particularly useful when you want to focus on a small group of speakers.

11.2.9 Clear button
Clear all speakers in the scene.

11.2.10 Add speaker button
Add a new speaker to the scene.

> Adopting the convention of the first version of Zirkonium, Speaker Setup adds the first speaker right behind the listener and give it index No.1. Then, it labels adjacent speakers counterclockwise by default. However, you are not obliged to follow this convention. If you prefer other numbering convention, please feel free to change the speaker index number.

11.2.11 Speaker Property Editor
In this pane, all properties of the selected speaker are displayed and the values are adjustable with either sliders or text boxes.

Two additional parameters are displayed at the bottom of this pane, when you selected absolute measurement system with the measurement system pop-up.

time to sweet-spot
Based on the provided data of speaker position, the software calculate automatically the approximate travel time of sound from the selected speaker to the sweet-spot. The speed of sound is predefined as 340 meters/sec. If the relative measurement system is selected, this field will be hidden.

delay for compensation
Delay compensation time based on metrical position of each speaker. If the relative measurement system is selected, this field will be hidden.

> If the distance between the sweet-spot and all speakers are not same, the sound generated by nearer speakers from the sweet-spot reach the sweet-spot earlier than further speakers. This may cause unintended Haas effects and possibly alter the sound quality. In order to avoid this problem, Zirkonium is able to apply slight delay to the signal fed to nearer speakers. This is called **delay compensation**. According to provided metric distances of speakers, Speaker Setup automatically calculates appropriate delay time for each speaker and store these suggested delay

time in the XML file.

In the absolute mode, the range of x, y, z position sliders in the property editor is limited from -25 (meters) to 25 (meters). If you setup loudspeakers for a larger space, please type the number directly in the text box.

11.3 Typical Setup procedure

The following is an example of speaker setup procedure:

1. Define the dimensionality of your speaker setup with the dimensionality pop-up. If the vertical position (i.e. the distance between the speaker cone and the floor) of all your speakers in your room are equal, select 2D, if not select 3D.
2. Select mode from absolute or relative with the measurement system pop-up. If the data of distances between sweet-spot and each speaker is at hand, select absolute mode. It is advised to choose absolute mode and measure the distance between the sweet-spot and the speakers, if the distance between the sweet spot and each speaker are not always equal.
3. Add an arbitrary number of speakers by clicking the “+” button several times.
4. If you want to categorize the added speakers into some groups, use “ring” pop-up menu in the speaker table and assign a new ring index to each speaker. You can filter the list by these ring index, using speaker filter pop-up.
5. Select created speakers one by one and enter the position of each speaker, using sliders or text field in property editor.
6. When you finish with the setup, click “export” button, name the XML file, and click the save button.

12. Appendix 3: ZirkoniumQTPlayer

ZirkoniumQTPlayer is a simple Quicktime player that accepts several simple OSC messages for playback. This enables you to synchronize a video and soundtracks that are spatialized with Zrikonium.

12.1 Installation, System Requirements

For the installation, simply copy the Speaker Setup to your Applications folder. The application runs Mac OS 10.5 or later.

12.2 Opening a Quick Time File

To open a quicktime file, select “open” from the file menu and select a quicktime movie in the open panel.

12.3 Preferences

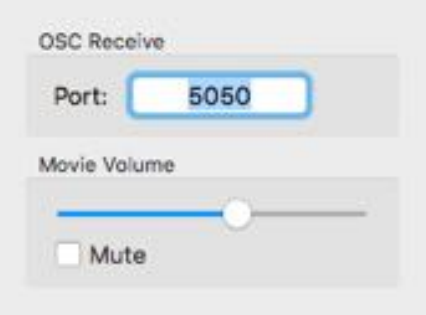


Figure 12.1: Preferences Panel

Preferences panel (fig:12.1) is accessible from **ZirkoniumQTPlayer -> Preferences...** menu. In the panel, you can specify a network port for receiving incoming OSC messages. The default port number is 1024 but you can change the port with the port text field. Movie volume slider controls the loudness of audio tracks. You can mute the audio instantly by checking the Mute check box.

12.4 Synchronizing with Zirkonium Trajectory Editor

To synchronize QTPlayer with the Trajectory Editor, the Trajectory Editor should send OSC messages to the QTPlayer. For the configuration open the network settings sheet by selecting **File -> Network Settings**.

Figure 12.2: Adding OSC Sender that sends messages to QT

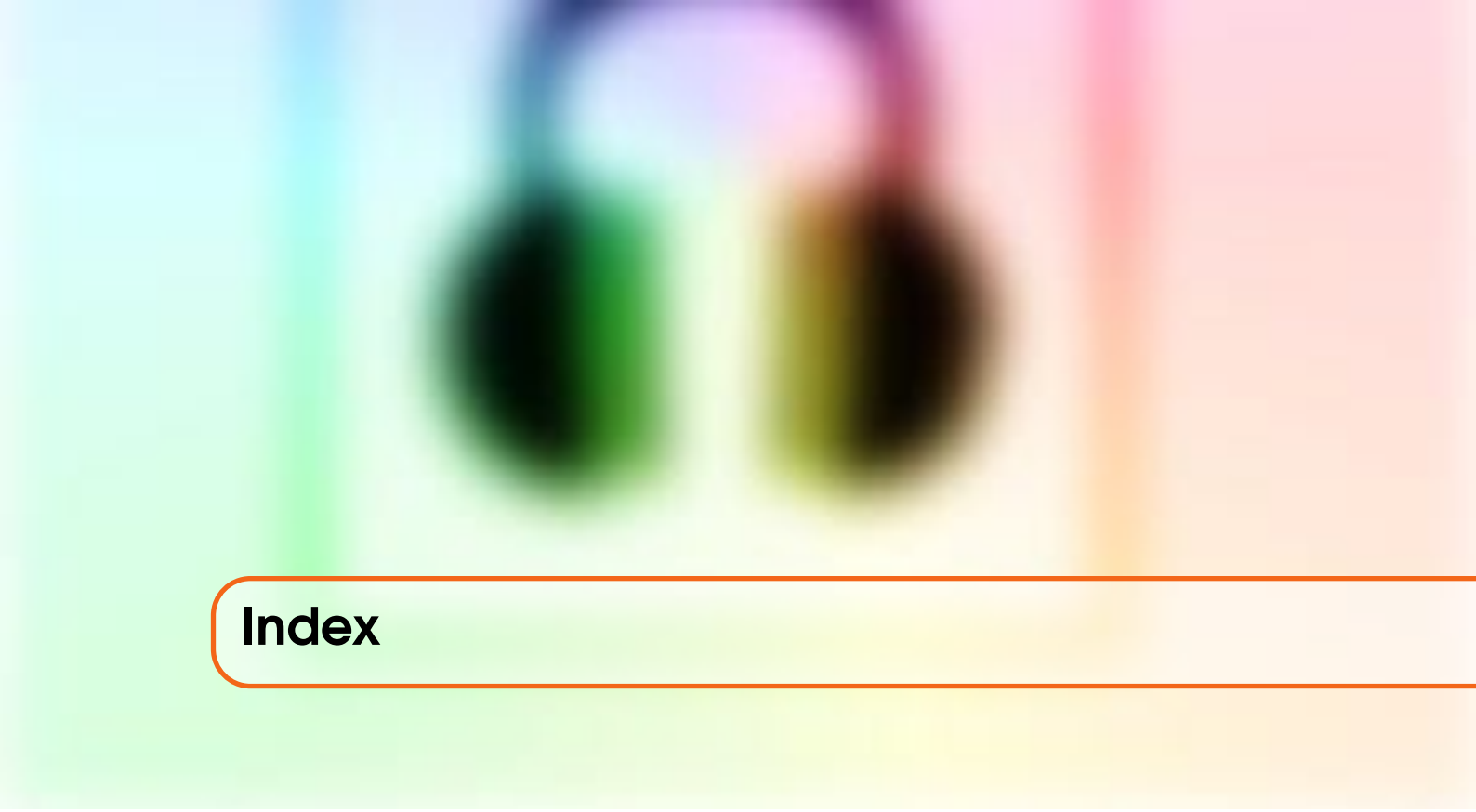
In the "add sender" field in the Network Settings sheet. Enter the IP address of the computer on which the QTPlayer is running and the configured Port. If you run the QTPlayer on the same machine, enter 127.0.0.1 (loopback) in the IP address field and press "+" button (Fig. 12.2).

Figure 12.3: Check the QT column

Then the created OSC sender will be displayed in the OSC Sender table. In the table, check the QT column (Fig. 12.3). Now the Trajectory editor is supposed to send OSC messages to ZirkQTPlayer.

R ZirkQTplayer starts the playback simply when it receives a OSC message. There is no mechanisms that evaluate the check the synchronization and correct it during the playback.

R It is also possible to send OSC messages to multiple computers in the same network and start QT movies on several computers simultaneously. To do so, define multiple OSC sender in the OSC Sender table.



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