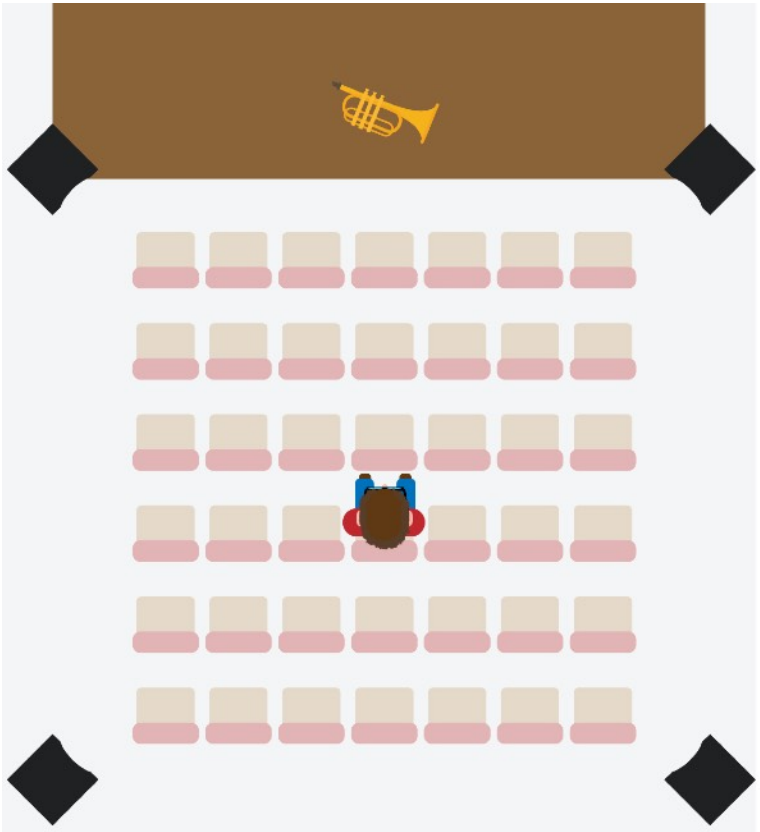
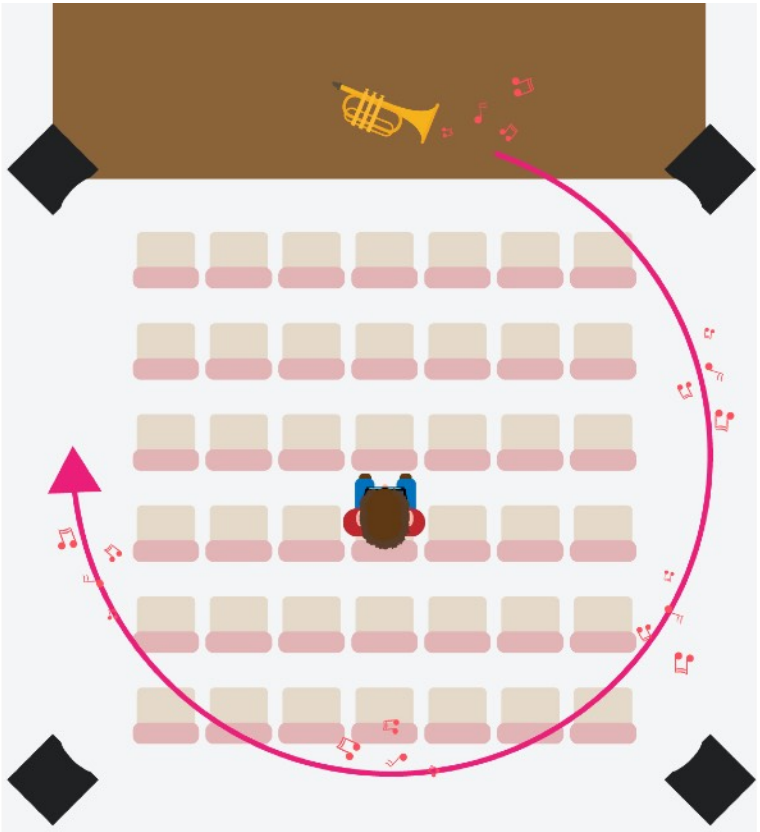

TOMMASO ROSATI
ELECTRONIC MUSIC
SPATIALIZATION
Photo: Mario Carovani

Spatialization

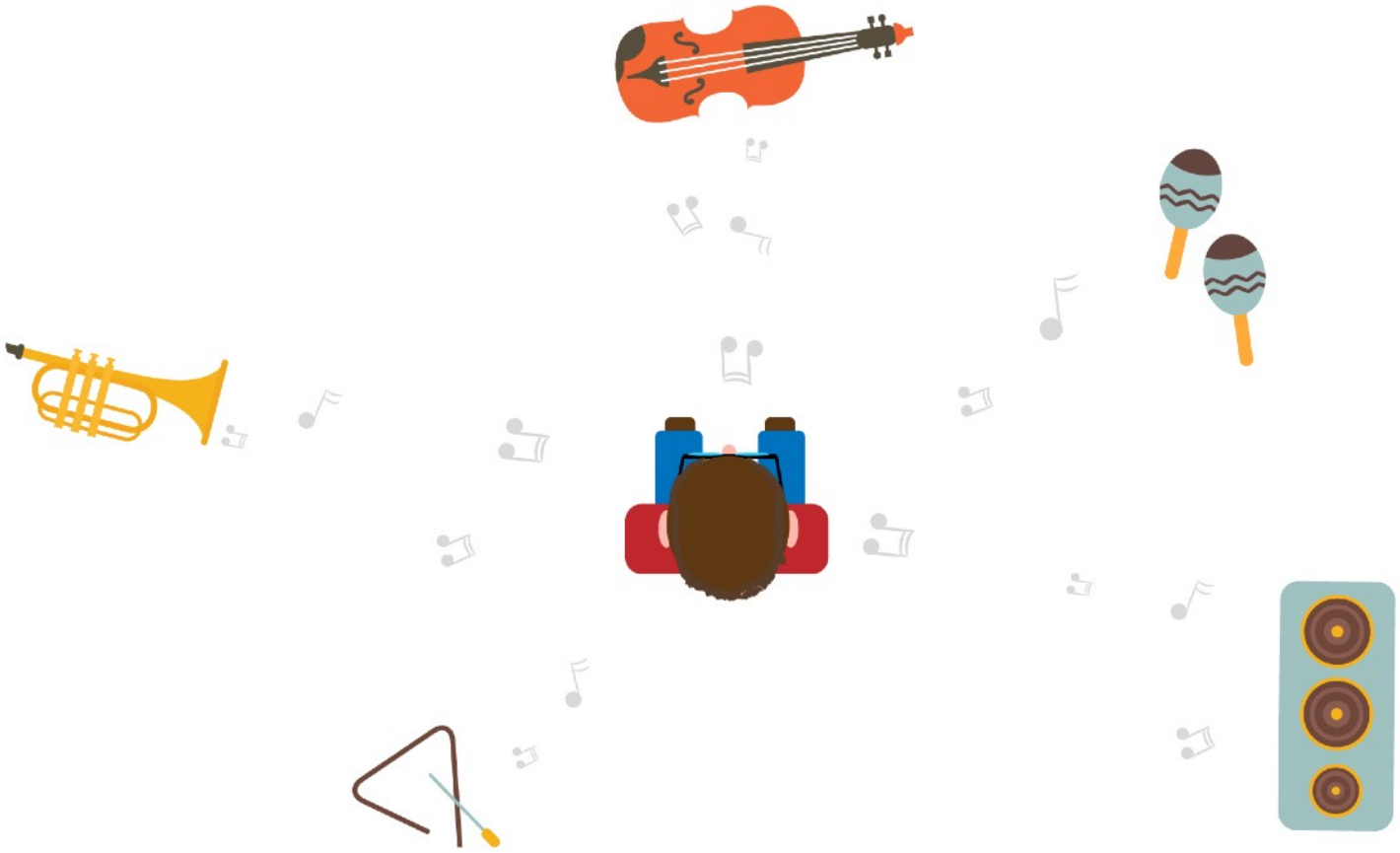
It is a compositional parameter that indicates the positions in space of the sounds in my composition, whether it is an electroacoustic composition or live electronics. They can be **static** positions or **dynamic** positions.





How do we perceive the space?

We can perceive the position of sounds because of the interaction between the ear and the brain. We are able to decipher whether a sound is coming from above or below, from the front or from behind, from the right or from the left with a high degree of accuracy.

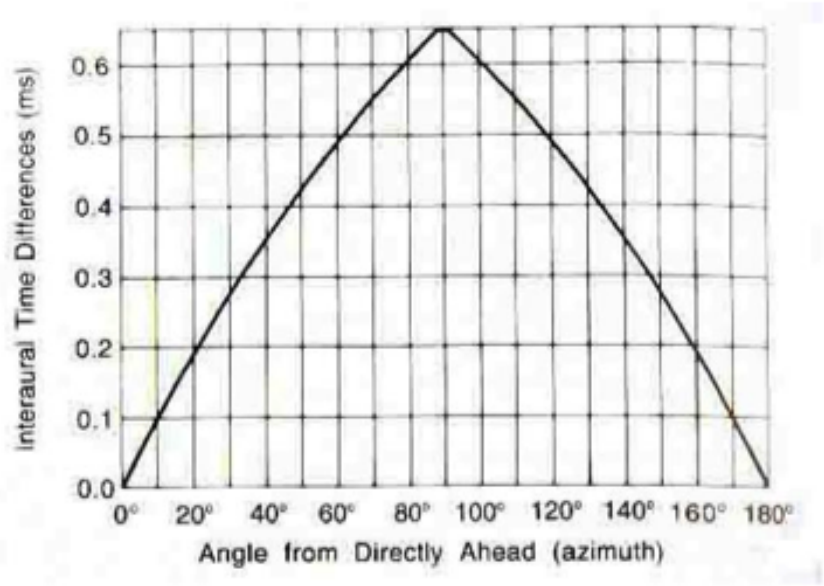


How do we perceive the space?

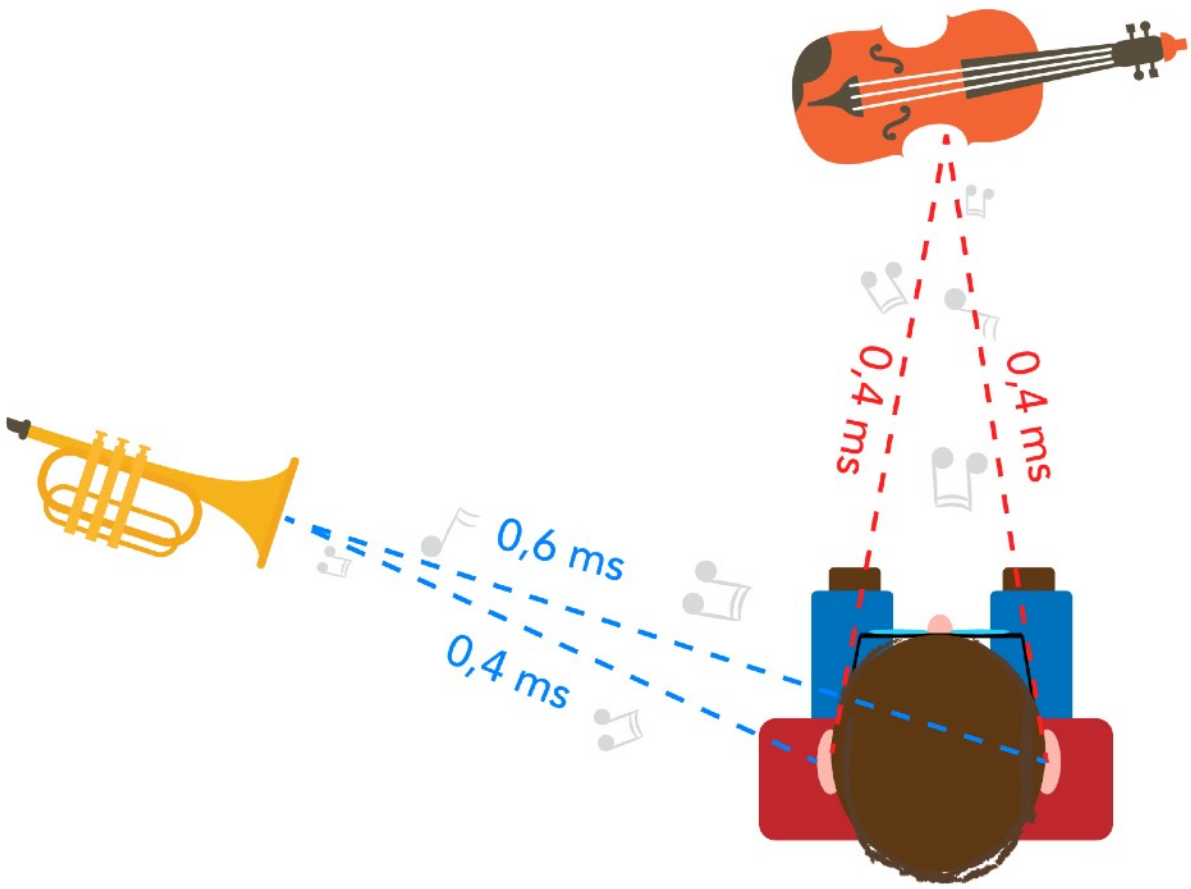
There are 3 basic parameters that allow us to perceive the space position of a sound:

1) **Interaural Time Difference (ITD)**

It expresses the delay with which a sound reaches the two ears.
For example, a sound coming from the right will reach the right ear in less time, and a sound coming from the left will reach the left ear in more time. The difference between these two values is the ITD.



How do we perceive the space?



ITD

Interaural Time Difference

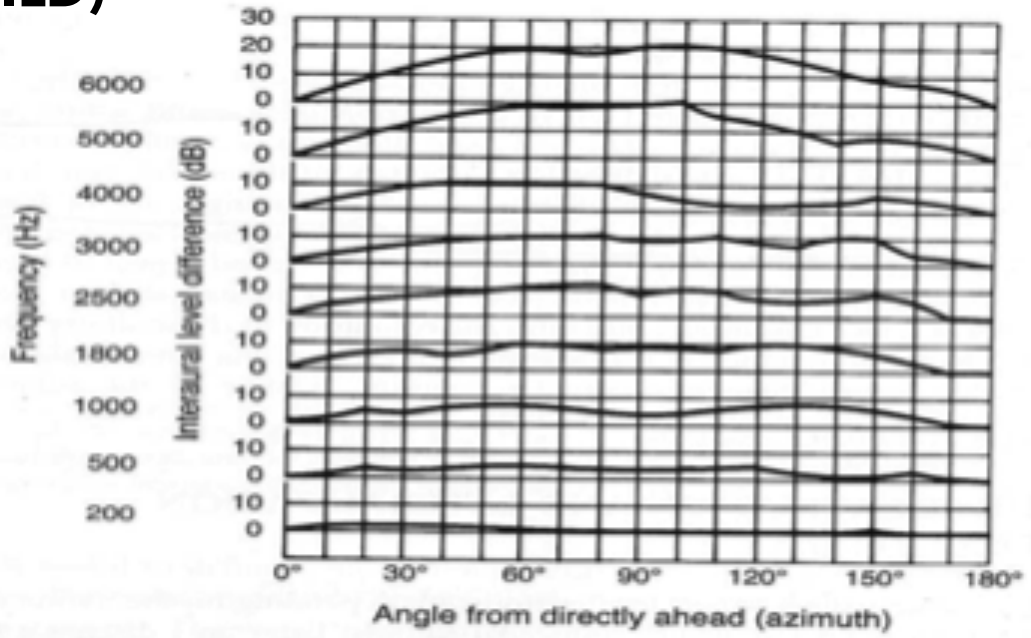
= 0 ms

= 0,2 ms

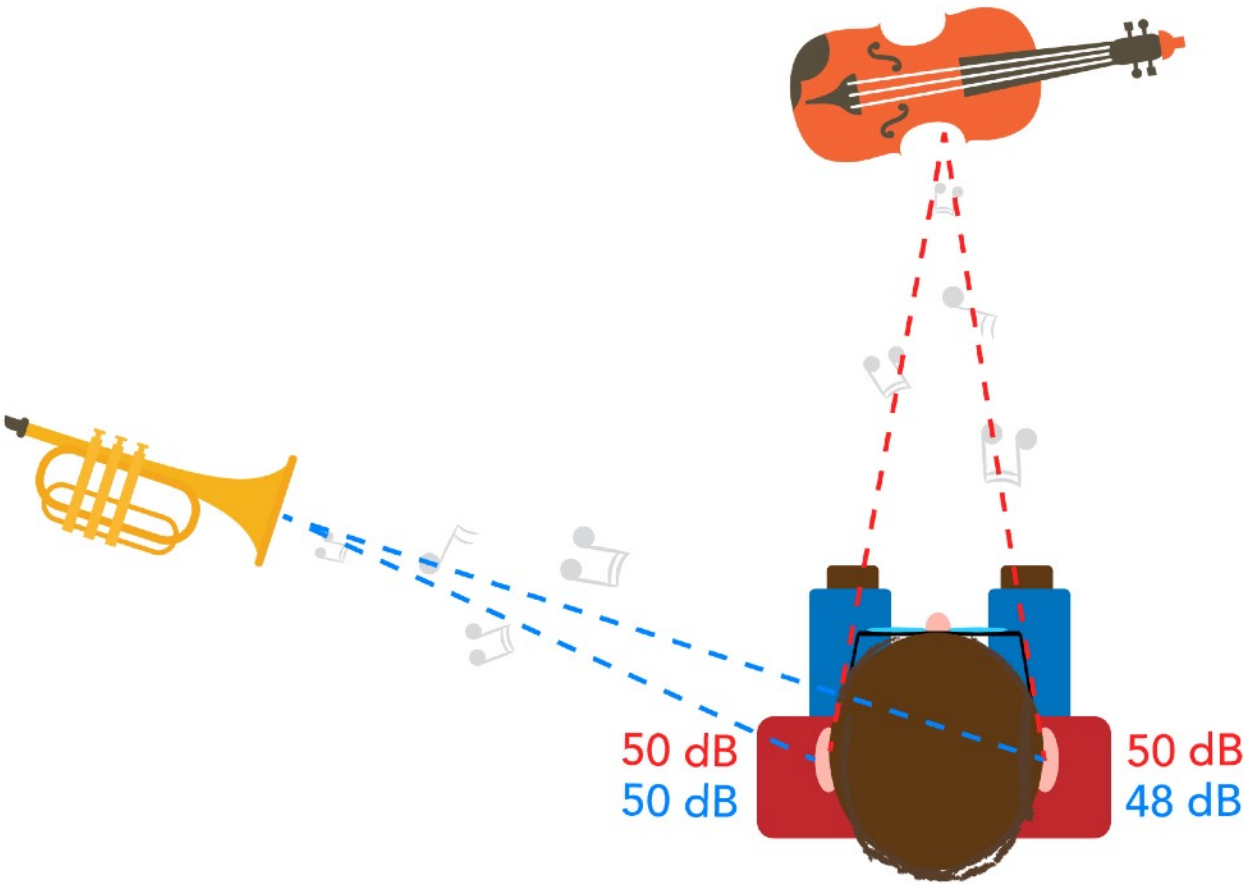
How do we perceive the space?

2) **Interaural Level Difference (ILD)**

It expresses the difference in sound intensity that reaches the two pinnae. For example, a sound coming from the right will reach the right ear with greater intensity than the left. The difference between these two values is the ILD.



How do we perceive the space?



ILD

Interaural Loudness Difference

= 0 dB

= 2 dB

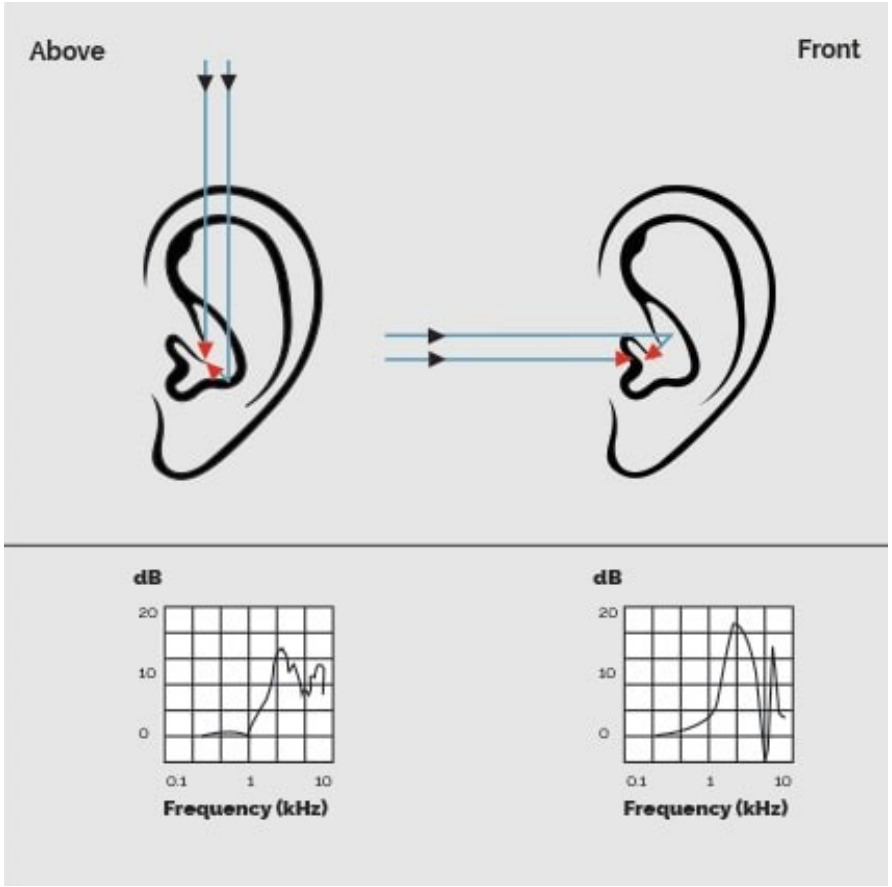
How do we perceive the space?

3) **Direction Dependent Filter (DDF)**

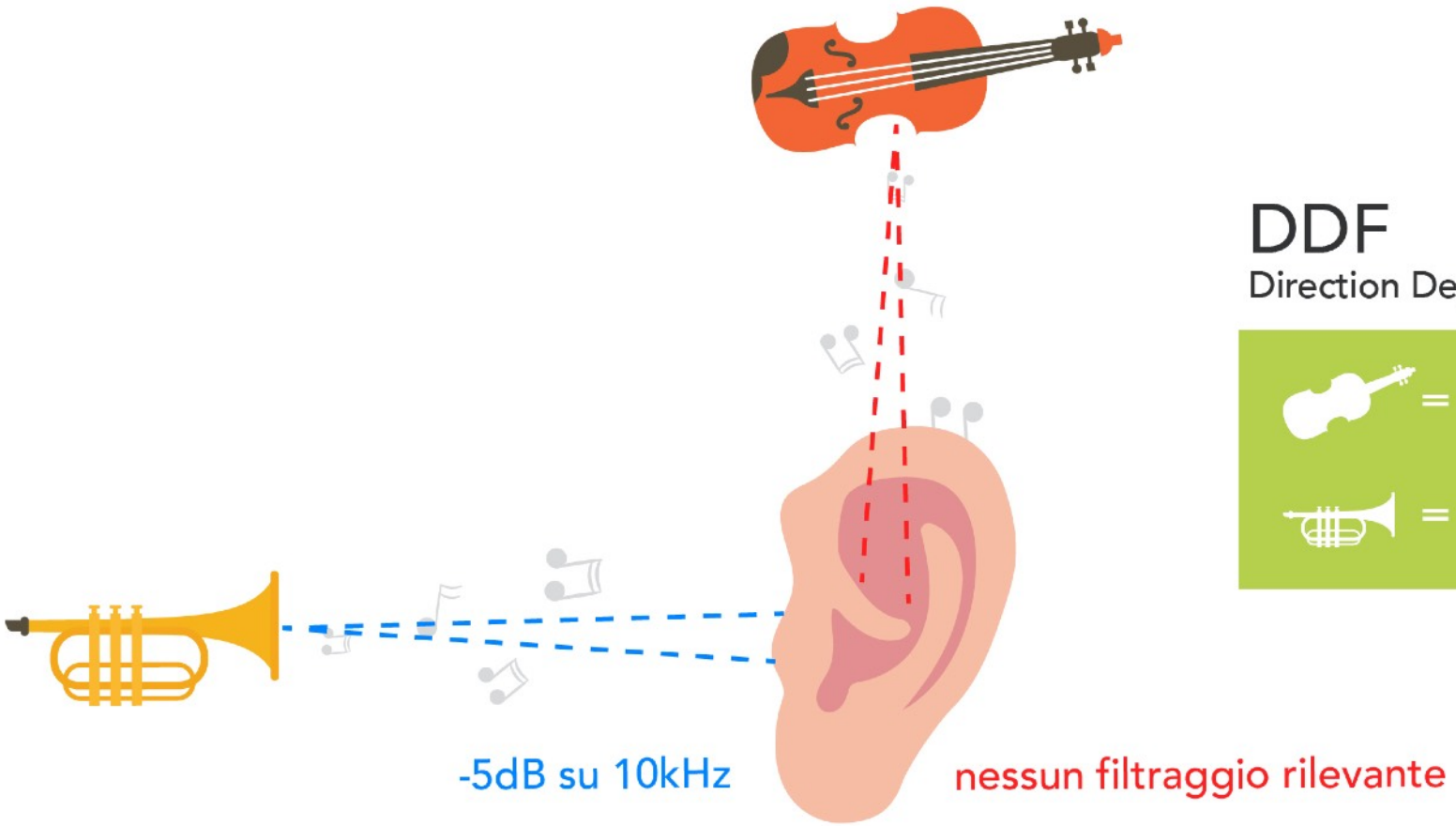
It expresses the filtering of sound by the inner and outer ears as well as the head and torso. Filtering is the attenuation of certain frequencies present in the timbre of a sound.

The irregular shape of the human ear allows sound to reflect and refract differently, depending on whether it comes from one direction or another, causing it to be filtered out. These modifications are then passed to the brain, which interprets the content in a spatial sense, as happens with touch or smell.

For example, a sound attenuated by 10 Db and filtered by 5 Db on 10KHz that arrives to the left ear will most likely be located in the upper right.



How do we perceive the space?

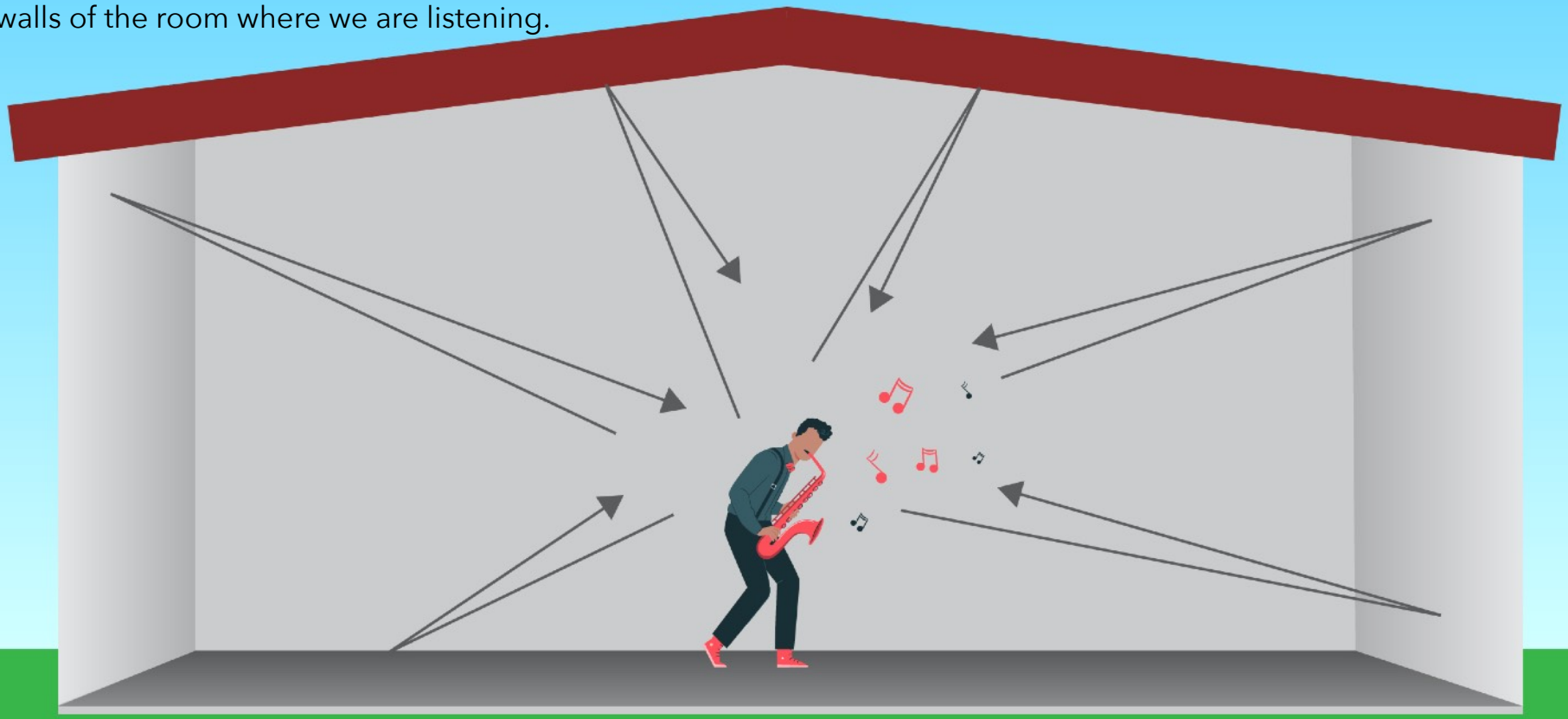


How do we perceive the space?

The environment

Reverberations due to the environment in which we listen to sound play an important role in sound localization.

For example, a sound with a lot of reverberation is usually perceived as distant. This is because a distant sound makes our auditory system receive not only the direct sound but also the sound coming from the bounces on the walls of the room where we are listening.



Spatialization systems

A spatialization technique is a system for **virtually moving a sound source through space**.

There are many spatialization systems with varying degrees of complexity. A good spatialization system is one that takes into account all the parameters described in the previous slides: ITD, ILD, DDF, and environment. Clearly the more parameters involved, the more calculations the computer has to make and the more accurate the spatialization will be.

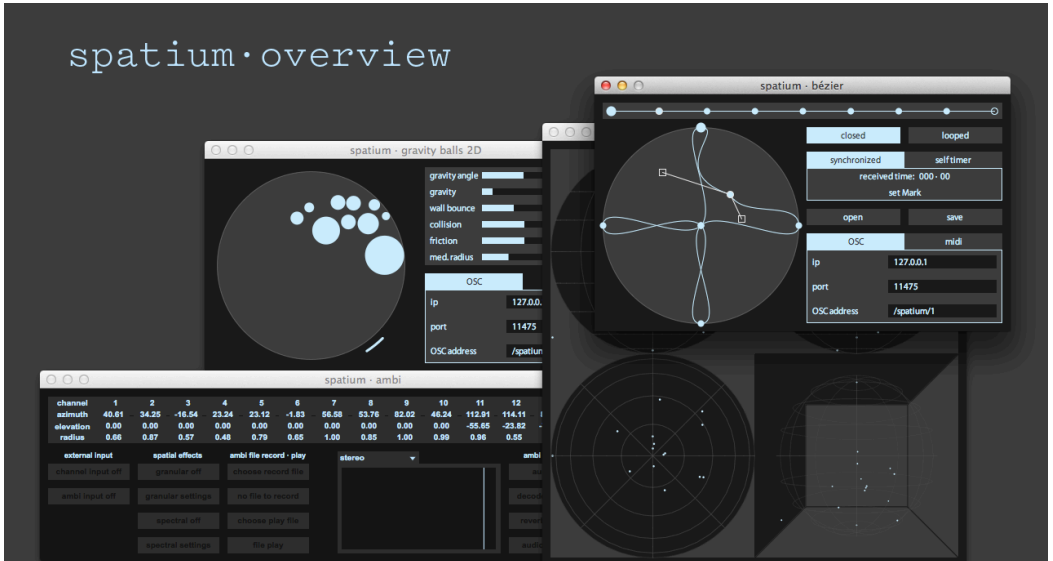
Spatialization systems

hardware: dedicated machines therefore more expensive and less common

front

back

software: these are programs executed on computers that allow spatialization



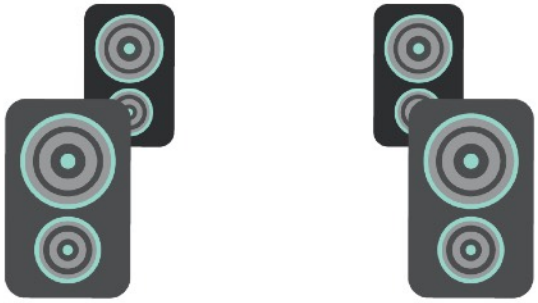
Spatialization systems

Binaural spatialization

Spatialization done directly in headphones is called binaural and is also based on the deception of our auditory system working on the perceptual parameters that we have just seen: ILD, ITD, DDF and reverberation. It is particularly used associated with virtual reality systems with 3D viewers in the world of gaming, for example.

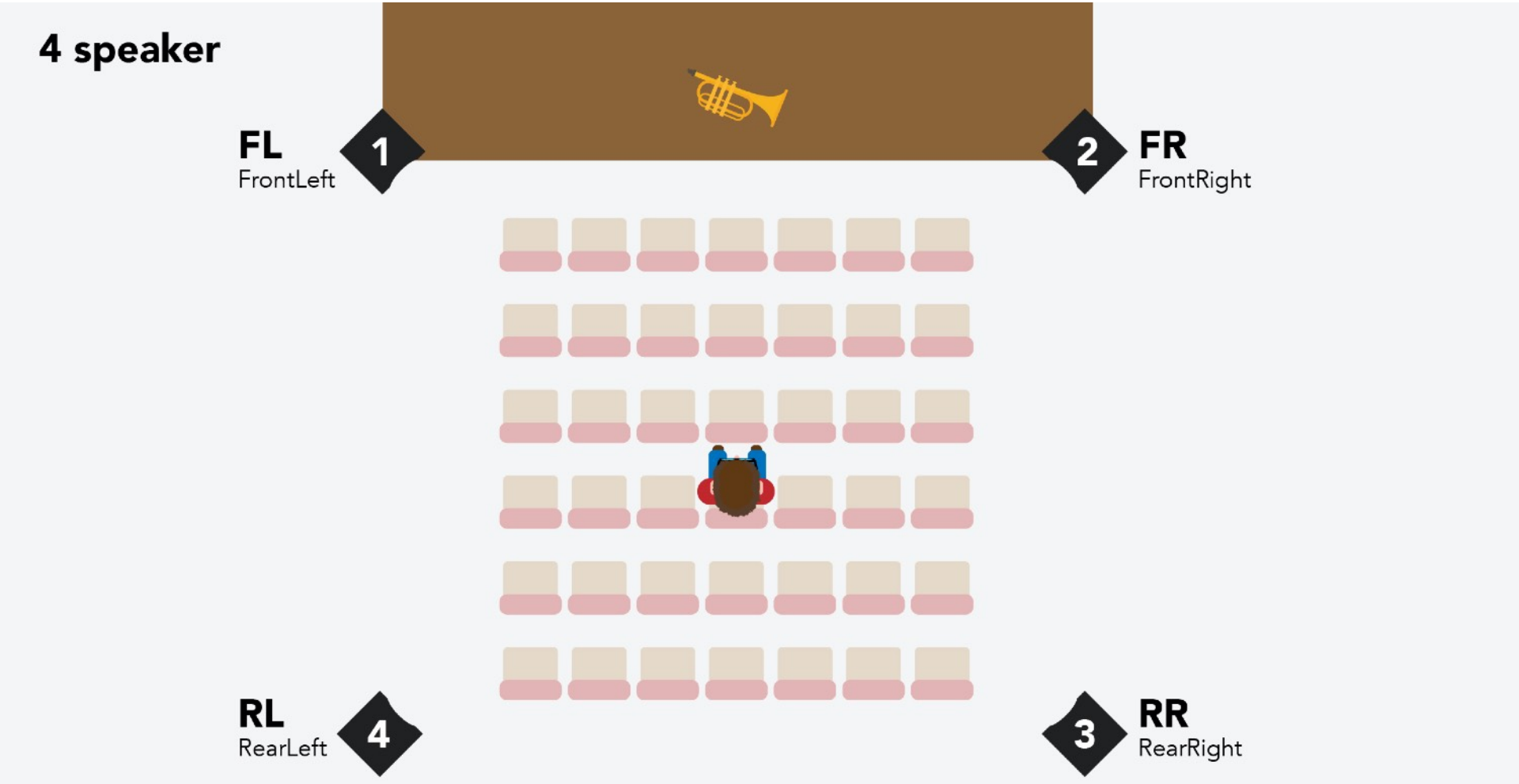
Spatialization with speakers groups

In your own studio or in a concert (not silent because in that case listeners are provided with headphones) it is possible to spatialize through a certain number of speakers. Spatialization can also be done with only 2 speakers, but clearly good results can be obtained starting from a quadraphonic system (4 speakers).

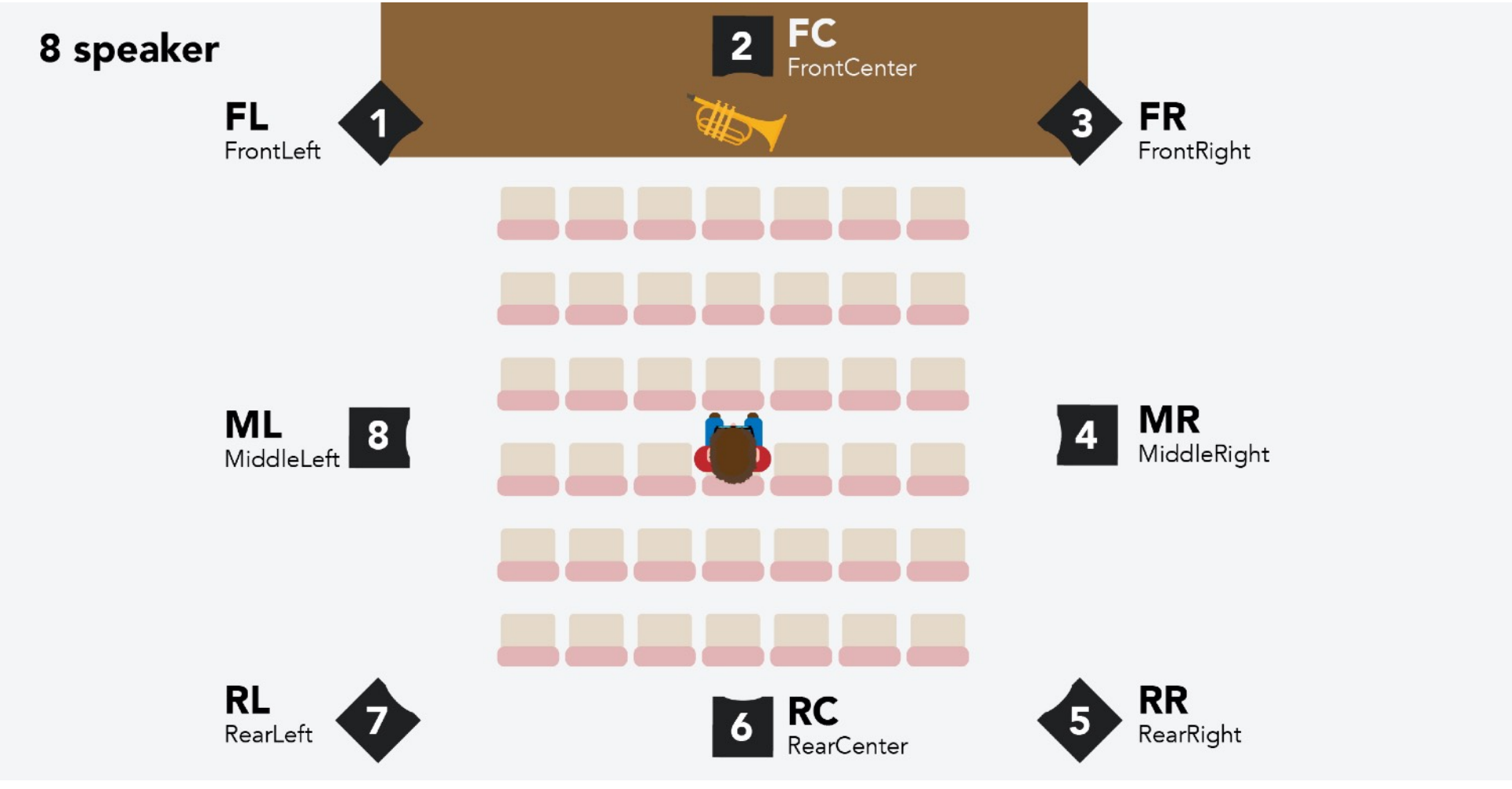


Spatialization systems

Usually in quadriphonic systems, speakers are positioned in this way:



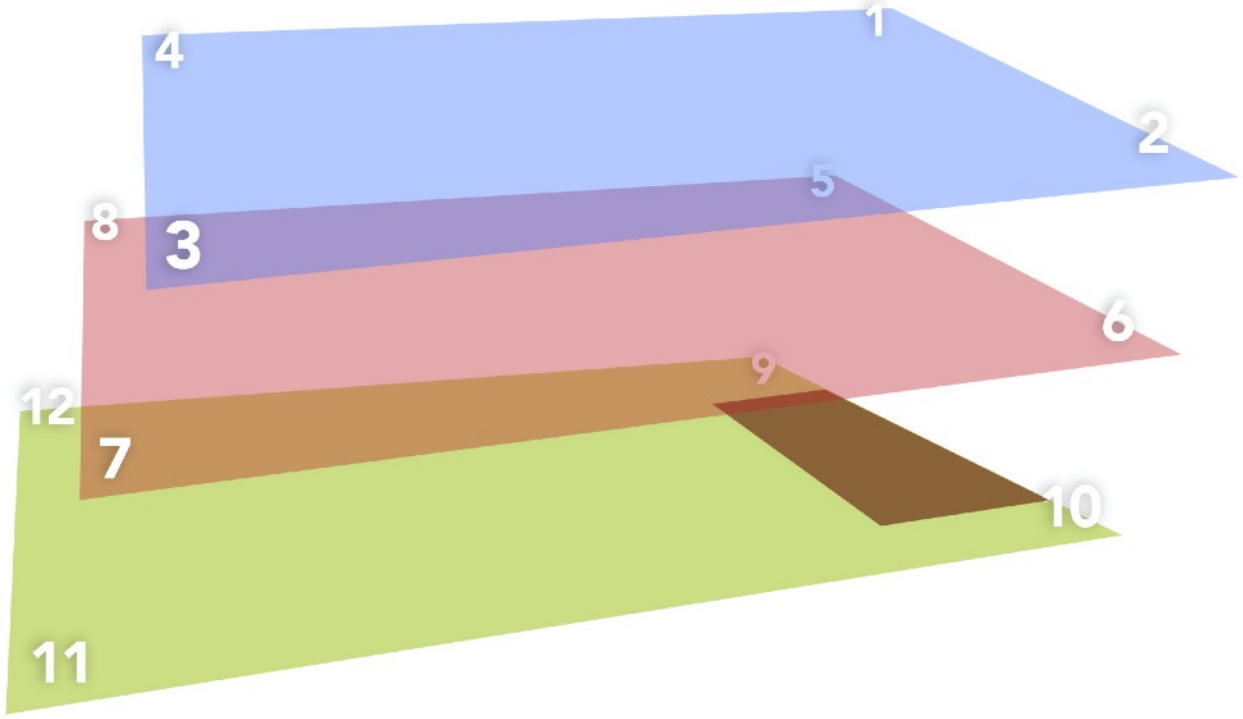
Spatialization systems



Spatialization systems

It is also possible to create more complex situations, for example using not just one order but several **orders of speakers** to make the spatialization of movements and vertical positions more accurate with respect to the listener.

12 speaker
su 3 ordini



Spatialization systems

Low frequency sounds

The low frequencies of the timbres we want to spatialize deserve a separate discussion.

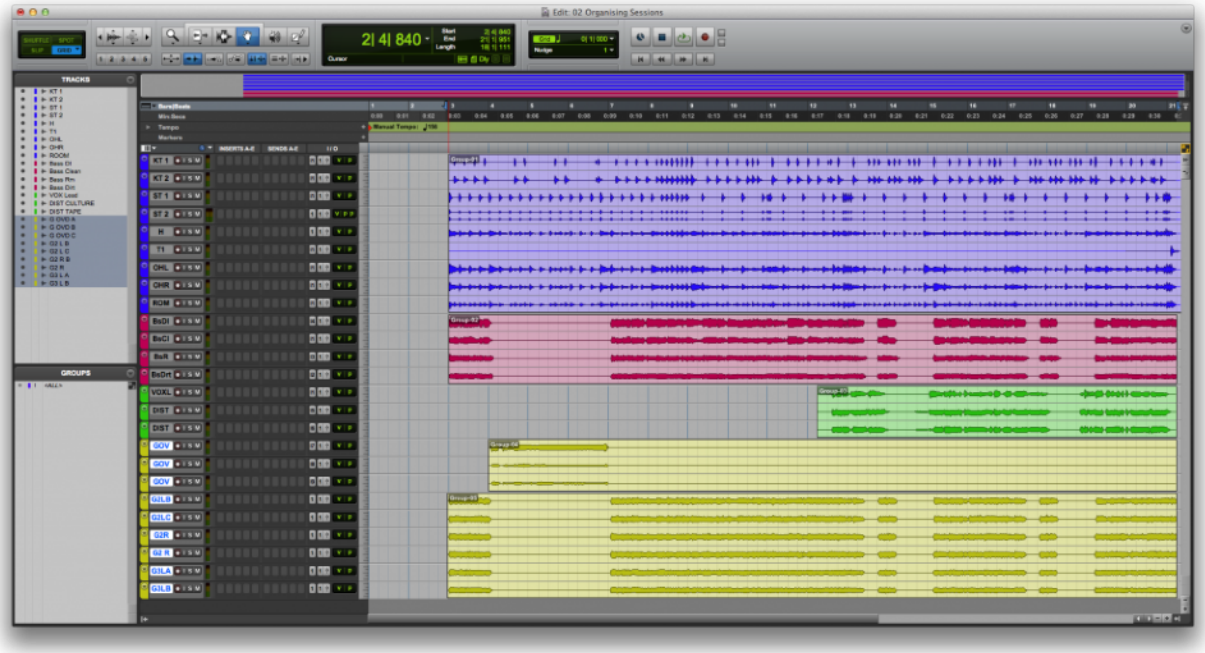
Here we are faced with a physical limit: bass frequencies (20-100 Hz) are difficult to locate in space, so usually for bass we use a speaker called a subwoofer that can be positioned anywhere in the room.

Control spatialization

There are two main ways to control spatialization:

In deferred time

You create the work during production in our DAW sotware, either by creating separate tracks for each speaker or by using a spatialization plugin that manages the various channels. During concert performance we use a track player that places each track on a specifi c speaker. This can be a computer or sometimes even a standalone player. This technique is often used to make electroacoustic tracks and electroacoustic concerts.



Control spatialization

In Real-time

You operate live to virtually move sounds through space. To do this, you can use a mixer or more sophisticated control surfaces such as multitouch surfaces (iPad...), joysticks or even sensors.

Ipad with LEMUR app communicating OSC

WII Remote controller connected with bluetooth

Panning

Panning is the adjustment of the position in stereo space of a sound. It indicates on which of the two speakers of a stereo system the sound is positioned.

The use of Pan is also a basic way of spatialization. In fact, it uses only one of our perceptual parameters of sound localization: the ILD.

It is adjusted through a potentiometer (**pan pot**) that can be found on all mixers, whether hardware or software (in DAW).

Panning

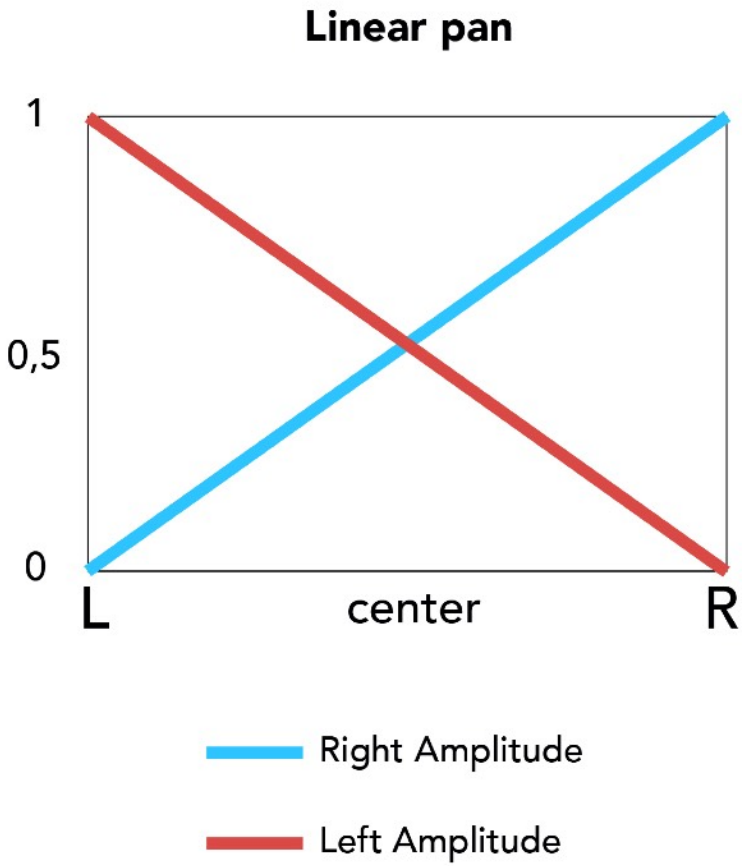
Panning algorithms

There are two main algorithms for panning:

Linear

This is a very simple algorithm, but it does not realistically match our auditory system. In fact, if I use this algorithm, when I am in the middle of the stereo front, I hear a general lowering of volume. This is because our auditory apparatus has a logarithmic response to volume (see dB scale...).

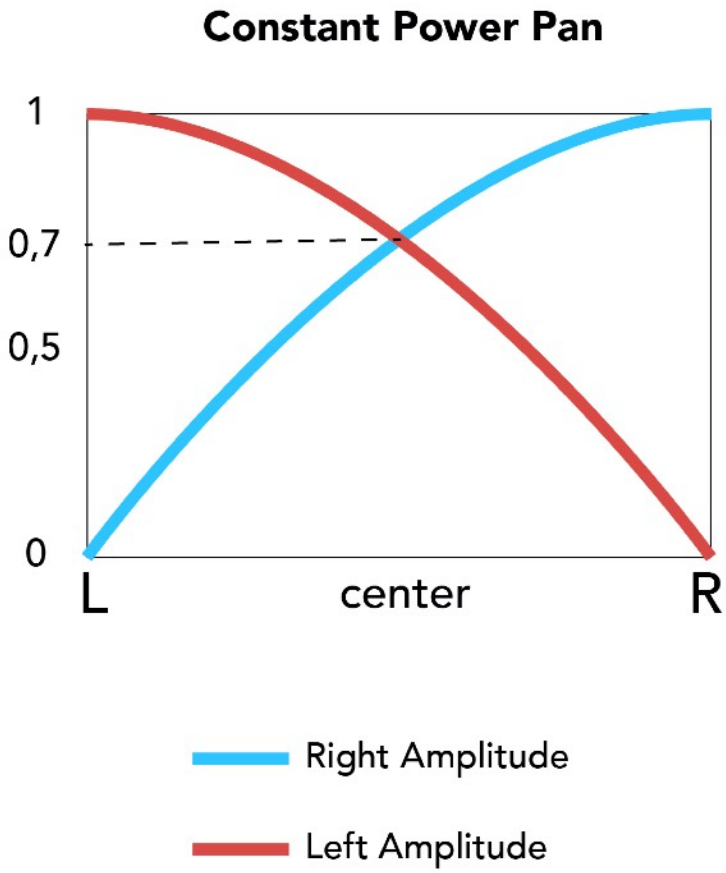
To achieve this, simply rescale the sound by multiplying it by values ranging from 0 to 1 in one speaker and inverse (from 1 to 0) in the other.
For example, if I multiply by 0 the sound that comes out of the left speaker, I have to multiply by 1 the sound that comes out of the right speaker, in this way I get a sound localized all on the right.



Panning

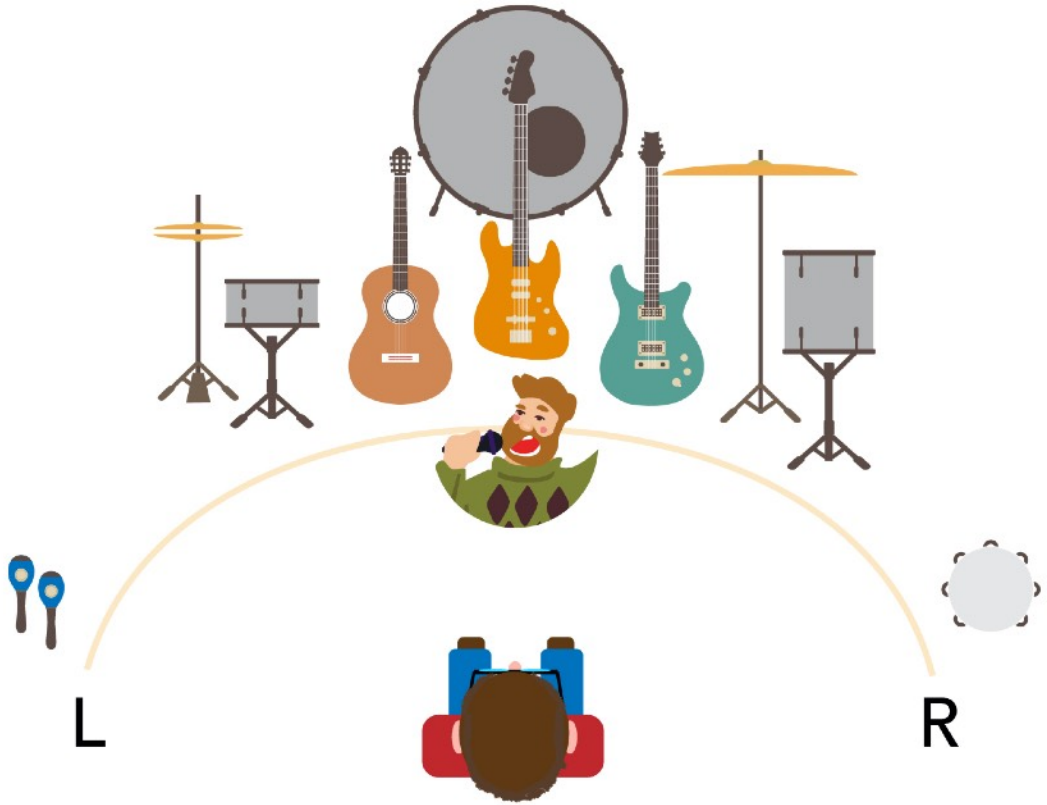
Constant Power Pan
It's a more accurate algorithm that allows you to localize the sound well. It follows logarithmic curves so I don't have the problem of lowering when I put my sound in the center.

To achieve this you proceed as in the linear scale but the multiplication values are put under square root. This makes the variations follow a logarithmic curve and not linear.



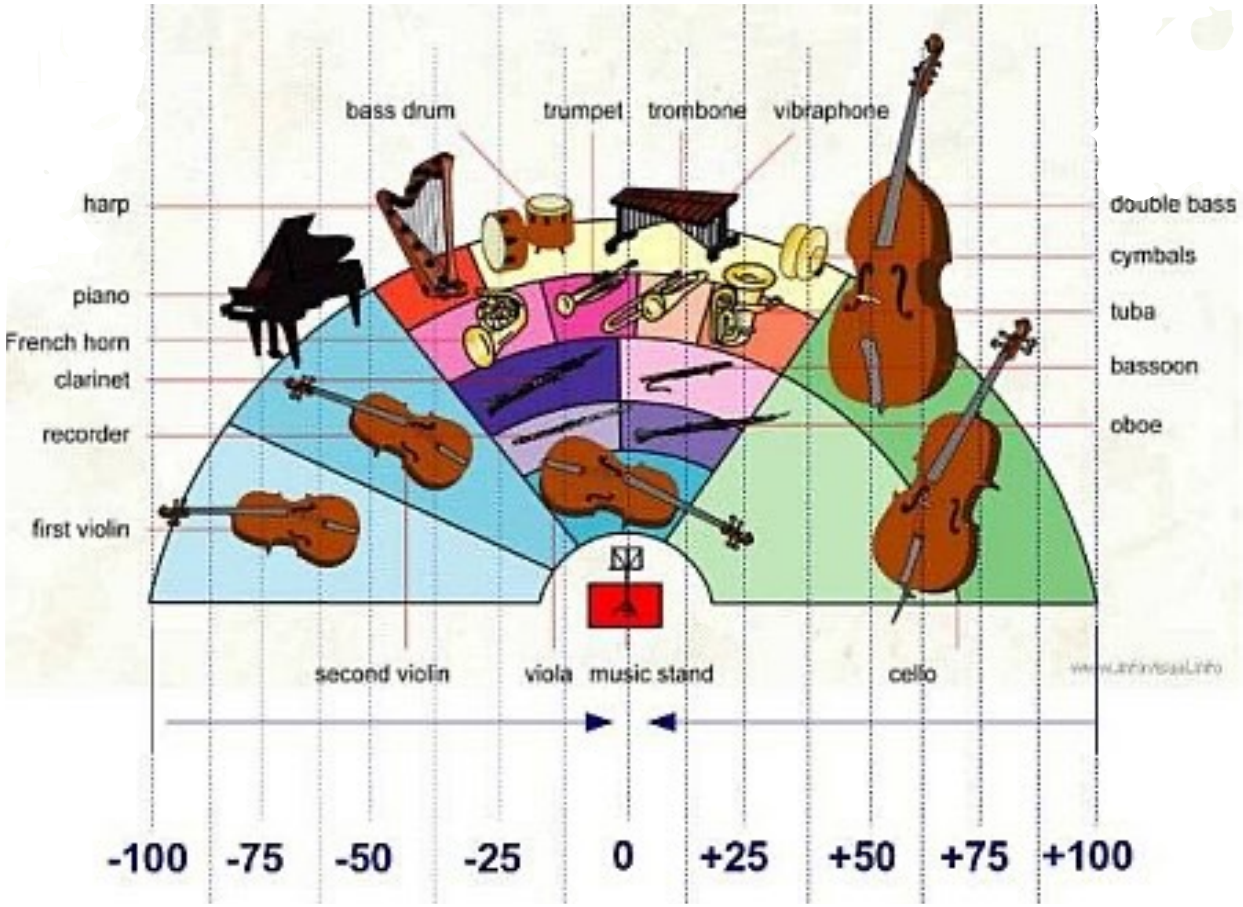
Space as a compositional-performative parameter

We can consider space as a true and proper compositional parameter. The composer can not only choose the position of the instruments in his composition, but also assign positions to the different notes of a single instrument, deciding the evolution of the piece over time.
The simplest thing that can be done in a stereo piece with simple panning is to distribute the various instruments in space. In this way the listener will hear the track as if he were in the room where the musicians are playing.
These are some of the classic positions of the instruments in a Pop, Rock or Jazz mix



Space as a compositional-performative parameter

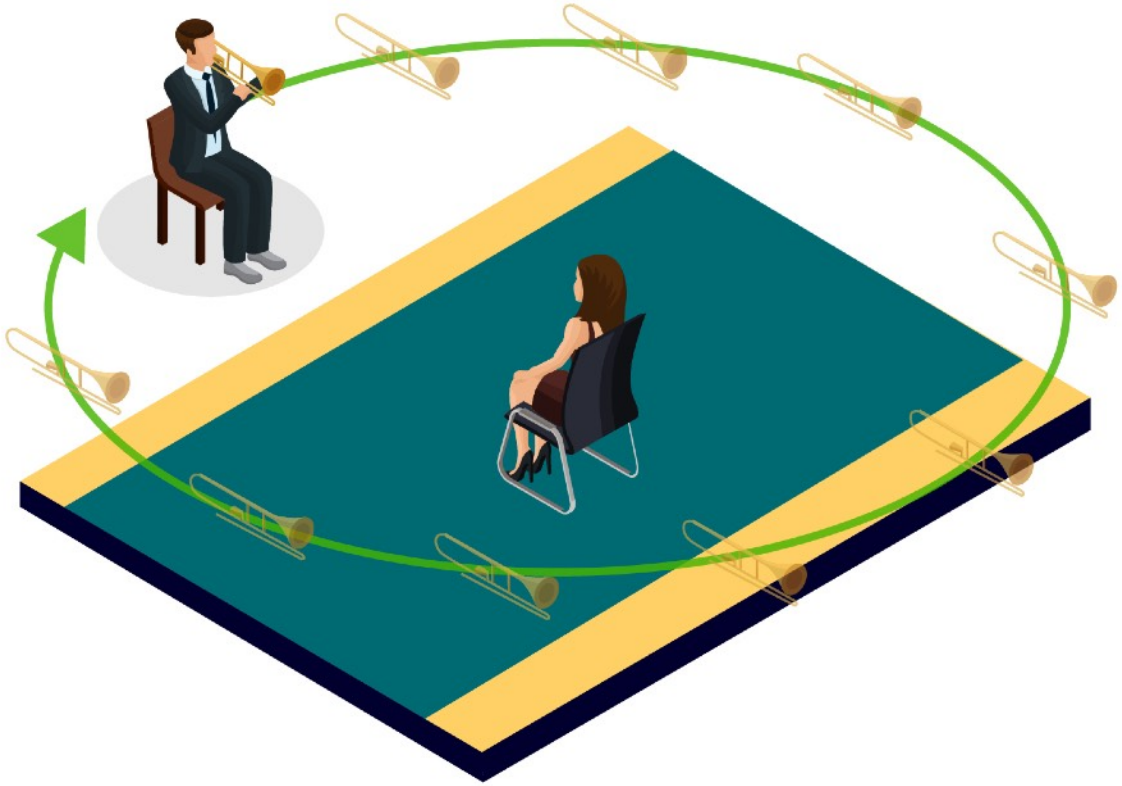
Clearly, the instruments of a **classical orchestra** also have their own position in the stereophonic front which could be of the type:



Space as a compositional-performative parameter

Spatialization is a **compositional parameter**, whether it is simple panning or a more complex spatialization system.

For example, I can make a section of my piece where the sound of a trombone goes around the listener.



Space as a compositional-performative parameter

Or make the sound of a violin in the coda of my piece move closer and farther apart.