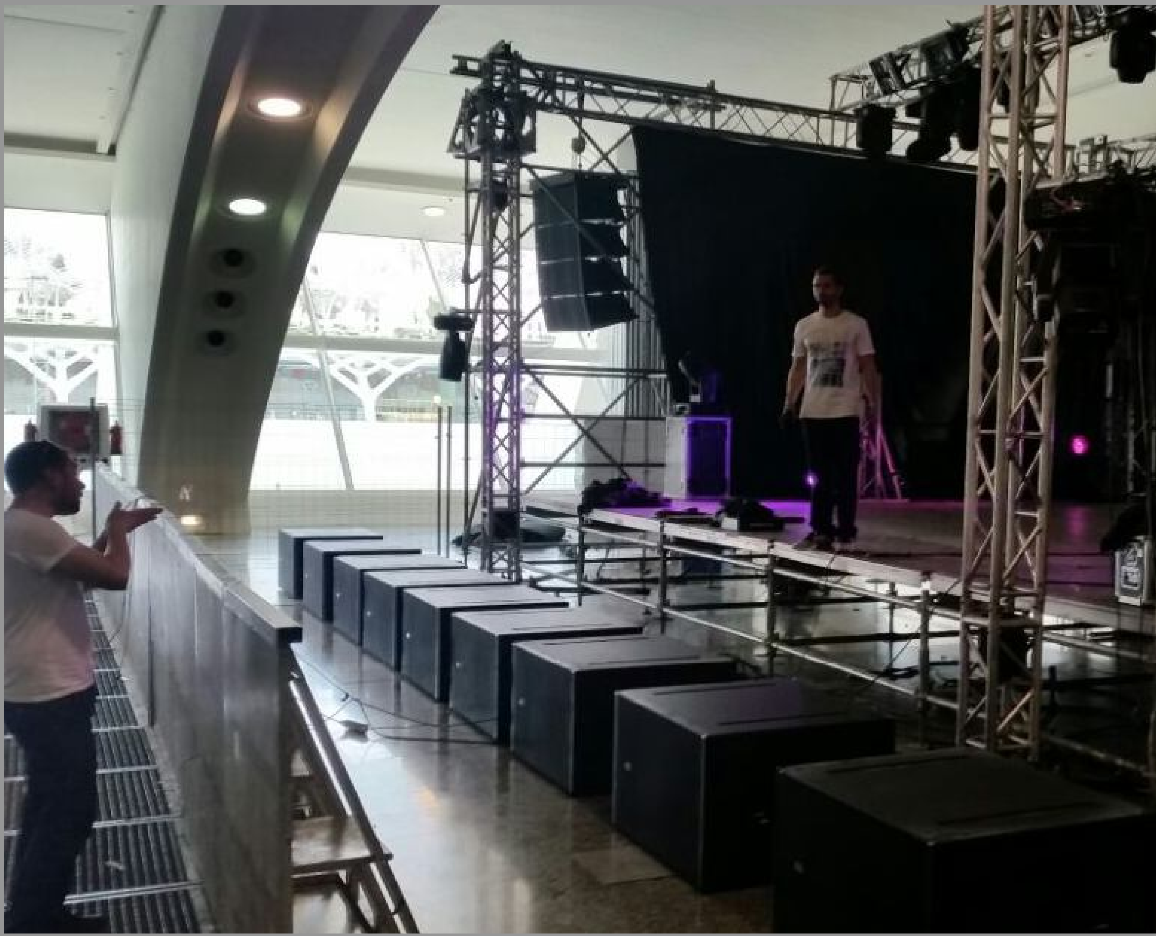
POSITIONING SUBWOOFERS

PRINCIPLE CONSIDERATIONS



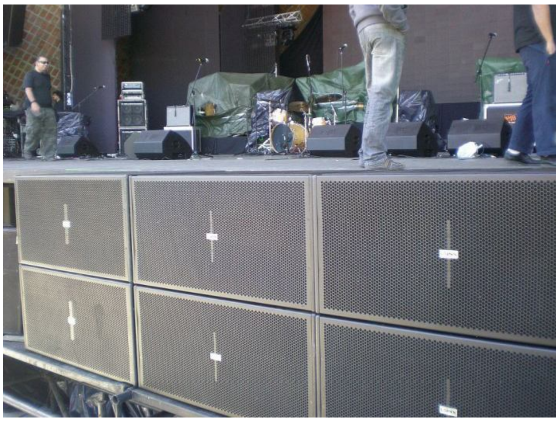
Lynx Pro Audio / Technical documents

When you arrive to a venue and see the Front of House you can find different ways how subwoofers are placed. Sometimes you can see the subwoofers in stereo mode under left and right tops, sometimes you can see them gathered in the centre of the stage, sometimes the subs occupy a horizontal line along the stage, they can be stacked, flown, both... and sometimes you don't know where they are because they are hidden.

The position of the subwoofers is very important because it can produces lobes of pressure and corridors of unwanted cancellations. And it usually coincides where the mixing desk is placed, causing the sound engineer to have a very different perception from other positions in the venue.

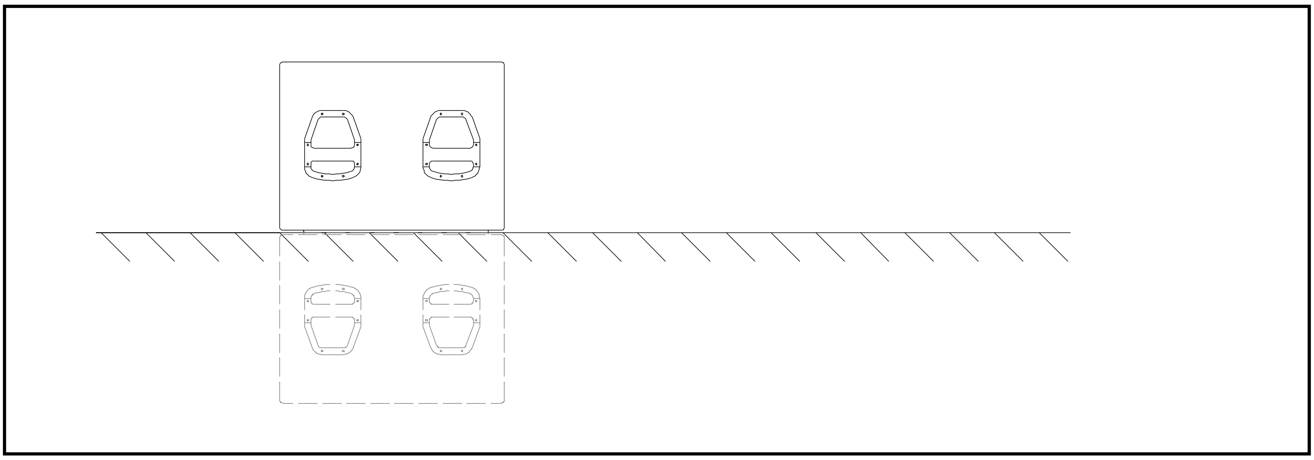
This document will show you how to place the subwoofers avoiding to make common mistakes. You will learn to calculate the proper distance of separation between each of them and how to use two excellent techniques, the in-line configuration and the electronic arch arrangement.

Are you ready ?



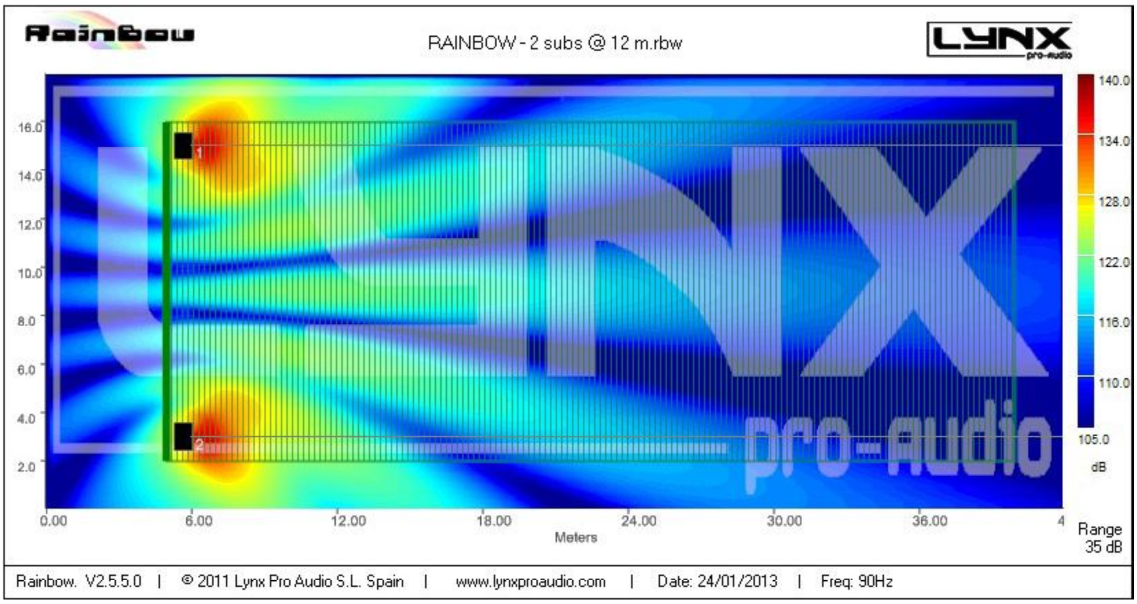
Before configuring any system you must bear in mind some technical factors which can be directly affected by positioning or cabinet processing.

Take an open air space without walls (ideal situation); if you use just one sub cabinet placed on the ground (most usual position), interaction with other elements is reduced to that which occurs with the ground reflection, causing an increase of 6 dB.



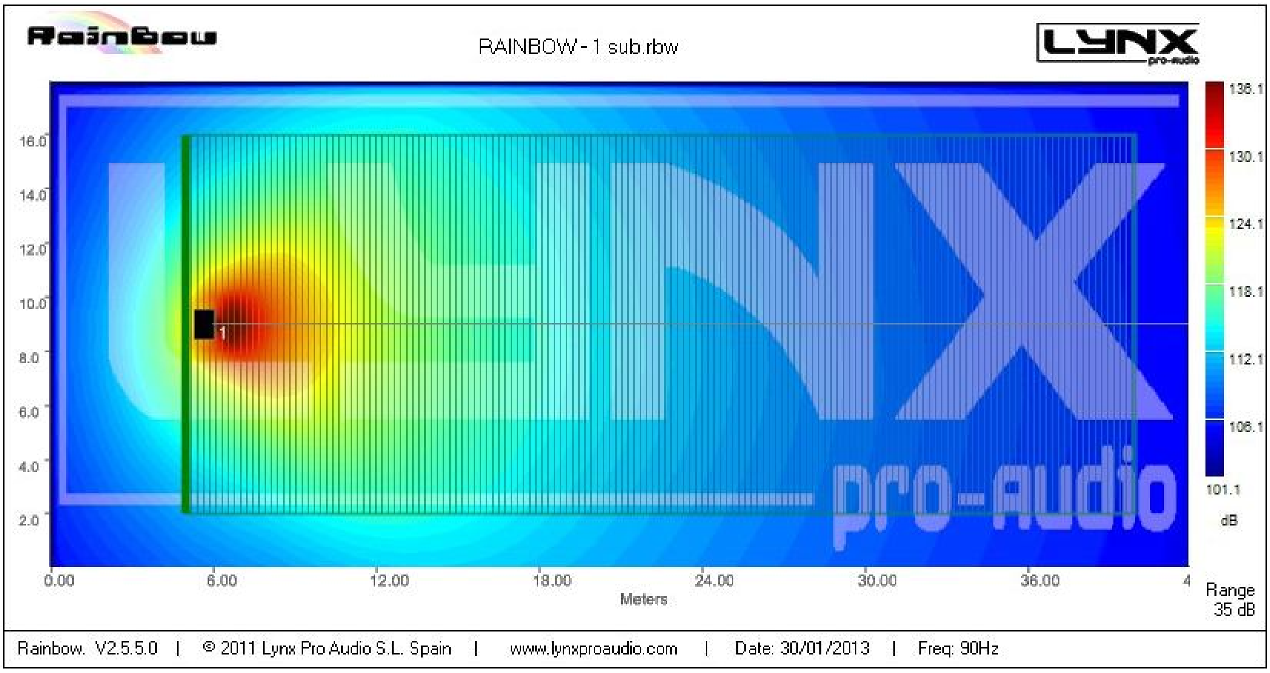
But when we add elements we need to consider its position with respect to the others to avoid unwanted cancellations in places where we need more pressure.

A bad positioning can produce lobes of pressure and corridors of unwanted cancellations, always in places where we need more pressure. And it is usually where the PA control is placed, so the FOH engineer has a very different perception from other positions in the venue.



Do you want to know more about the physical part? So let's start with the technical matters. You will see how subwoofers work.

The following image shows the pressure map of a LX218S subwoofer. Just one unit.



SPL MAP of LYNX LX-218S at 90 Hz

No more than 2/3 !

If we add one second subwoofer, it should not be placed over a greater distance than two-thirds of the wavelength of the maximum frequency that they are to played, measured from the center of a subwoofer to the center of the other. Ie, the maximum frequency will determine the maximum distance between the elements. This maximum distance will not be the only separation, ie, separation may be lower, leading to more pressure. For example, if we apply a low pass filter at 90 Hz (considering this its maximum frequency), we calculate the wavelength of this frequency and then calculate the distance of two-thirds of the resulting wavelength.

$$\lambda = \frac{V}{F}$$

λ: wave length in meters

V: speed in $\frac{m}{s}$

F: Frequency in Hz

$$\lambda\,(90Hz) = \frac{340}{90} = 3.77\ m$$

$$\text{Max. distance} = \frac{2}{3}\lambda$$

$$\text{Max. distance (90 Hz)} = \frac{2}{3}\ 3.77\ \text{m} = 2.51\ \text{m}$$

The maximum distance of separation permitted for two subwoofers whose upper cut off frequency is 90 Hz, is 2.51 meters (distance measured from center to center of the boxes).

If the maximum frequency was 100 Hz:

$$\lambda = \frac{V}{F}$$

$$\lambda\ (90Hz) = \frac{340}{100} = 3.40\ m$$

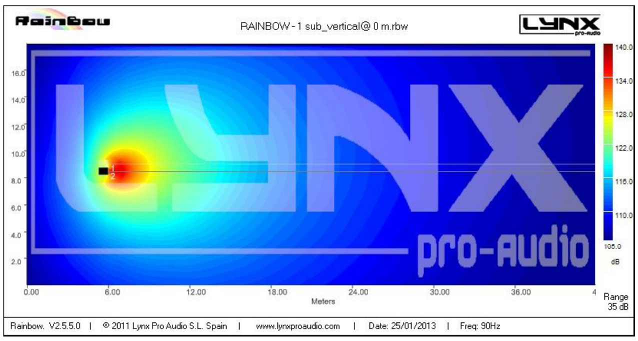
Max. distance $= \frac{2}{3}\lambda$

Max. distance (100 Hz) $= \frac{2}{3}$ 3.40 m = 2.26 m

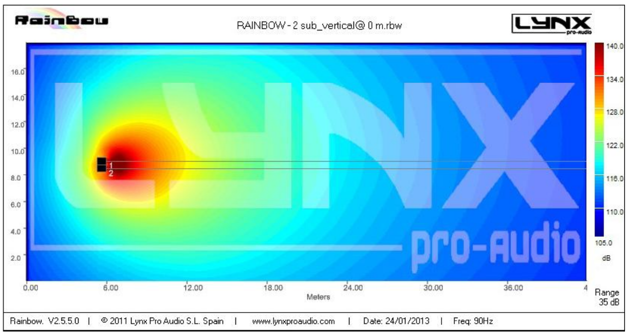
The maximum distance of separation permitted for two subwoofers whose upper cut off frequency is 100 Hz, is 2.26 meters (distance measured from center to center of the boxes).

From this maximum distance of separation, lobes of pressure and corridors of cancellation will start appearing, increasing in number at the same time as narrowing in coverage as the distance in separation is increased, always producing a lobe of central pressure, which coincides where the PA control is usually placed, causing the sound engineer to have a very different perception from other positions in the area. This effect is called a comb filter. Conversely, if this separation is close to zero, we get more pressure obtaining up to 6dB more (if used two of the same elements, with the same processing).

Placing the second element on top of the first (vertical stack), we get a sum of 6 dB as their separation is 0 meters (We consider a distance 0 when they are together, although it is not entirely accurate, because of the physical impossibility of exact positioning in the same point).



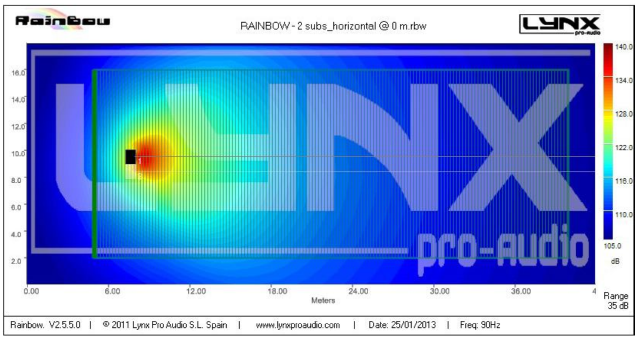
SPL MAP of LYNX LX-218S Vertical view



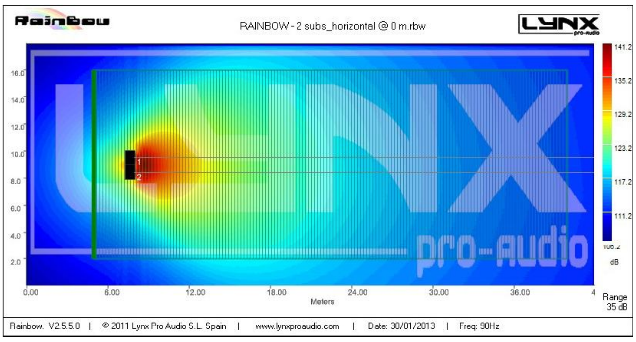
SPL MAP of two LYNX LX-218S Vertical view

In this last image the maximum amount of pressure is conserved, produced by two equal elements positioned vertically, one on top of the other.

The same applies if the positioning of the boxes is horizontal. (Consider, in this case, distance 0 when they are together, although it is not accurate, due to the physical inability to position them exactly at the same point).



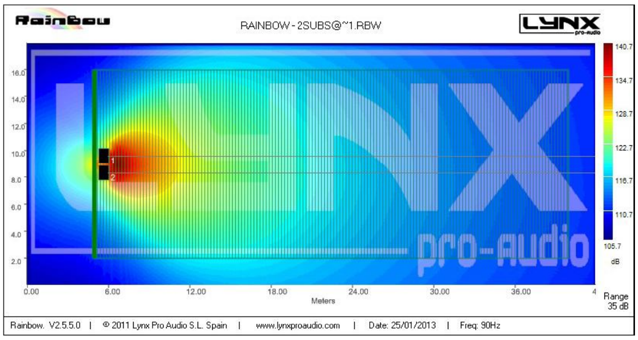
SPL MAP of LYNX LX-218S Horizontal view



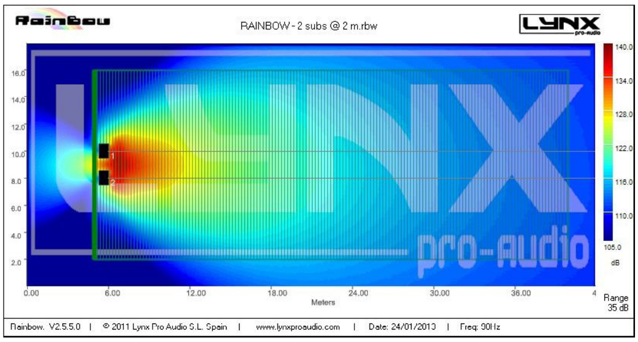
SPL MAP of two LYNX LX-218S Horizontal view

In the image on the right we can see the maximum amount of pressure produced by two equal elements, positioned horizontally next to each other is observed.

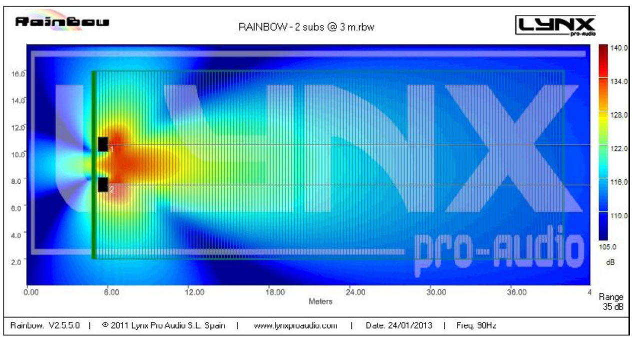
As we begin to separate the elements, observe how coverage of these varies, causing cancellations mentioned earlier.



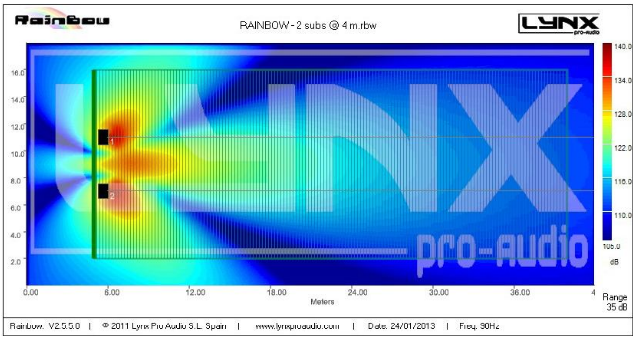
SPL MAP of two LYNX LX-218S separated 1,3 m. Horizontal view



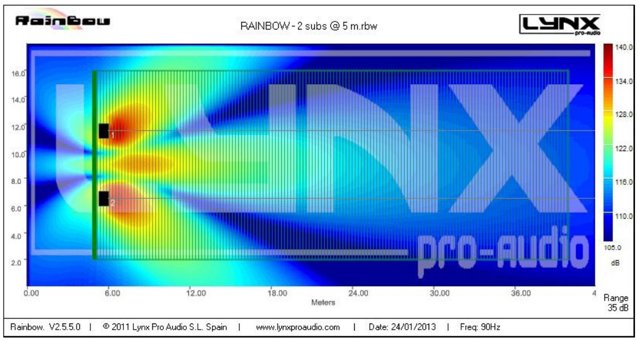
SPL MAP of two LYNX LX-218S separated 2 m. Horizontal view



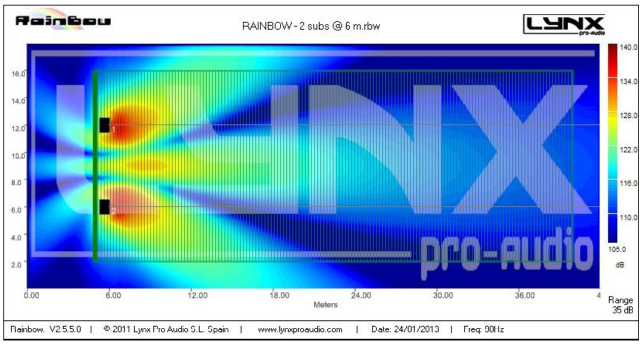
SPL MAP of two LYNX LX-218S separated 3 m. Horizontal view



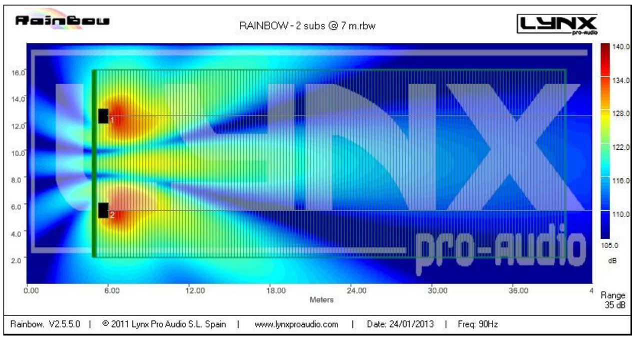
SPL MAP of two LYNX LX-218S separated 4 m. Horizontal view



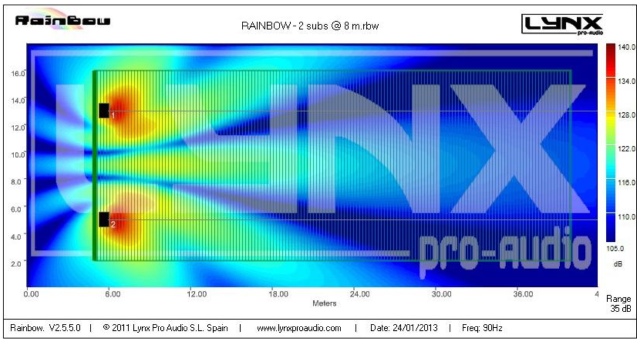
SPL MAP of two LYNX LX-218S separated 5 m. Horizontal view



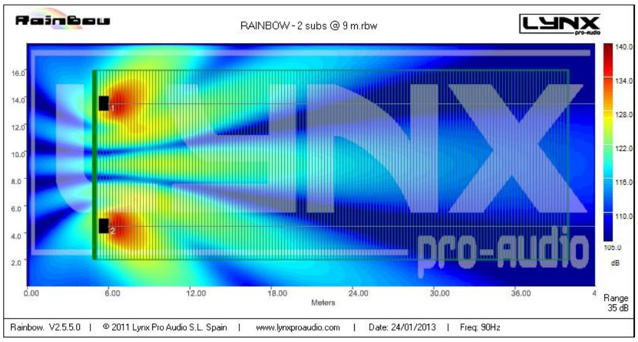
SPL MAP of two LYNX LX-218S separated 6 m. Horizontal view



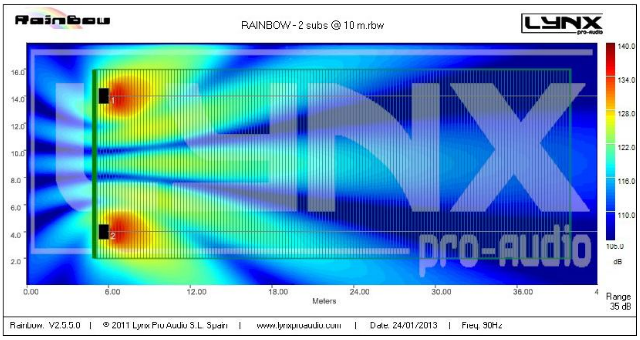
SPL MAP of two LYNX LX-218S separated 7 m. Horizontal view



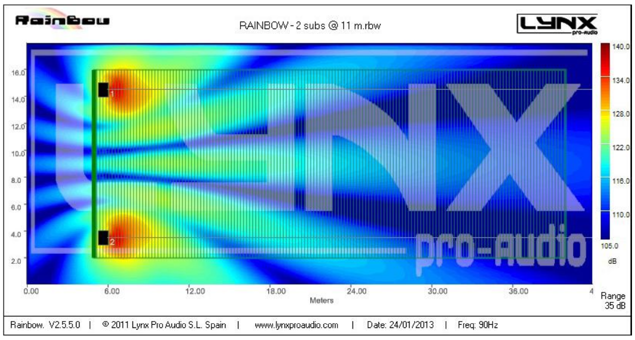
SPL MAP of two LYNX LX-218S separated 8 m. Horizontal view



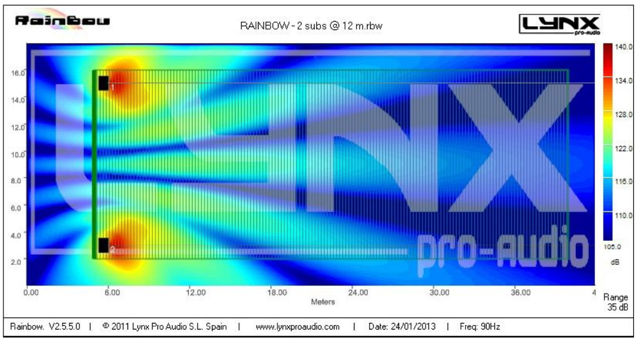
SPL MAP of two LYNX LX-218S separated 9 m. Horizontal view



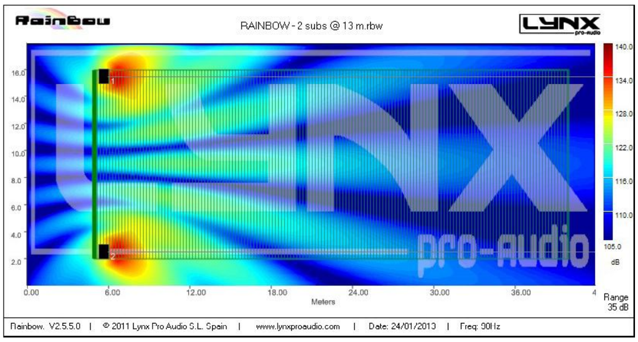
SPL MAP of two LYNX LX-218S separated 10 m. Horizontal view



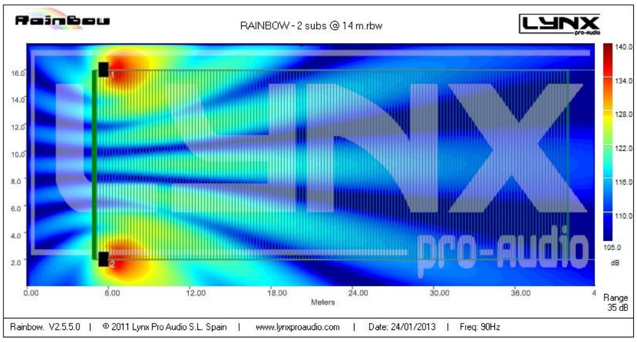
SPL MAP of two LYNX LX-218S separated 11 m. Horizontal view



SPL MAP of two LYNX LX-218S separated 12 m. Horizontal view



SPL MAP of two LYNX LX-218S separated 13 m. Horizontal view

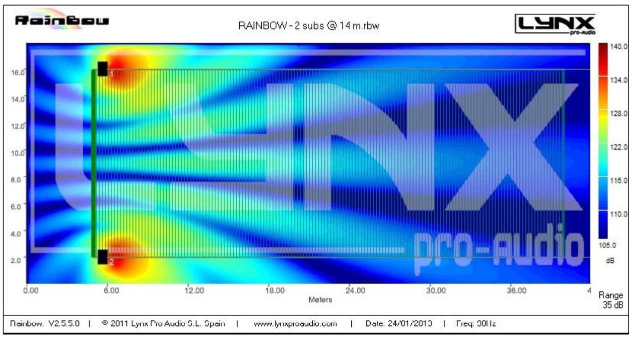


SPL MAP of two LYNX LX-218S separated 1 m. Horizontal view

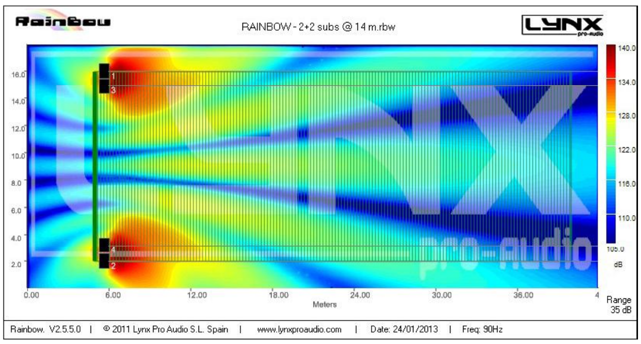
In the above sequence of images we can clearly see the effects of the comb filter, produced by excessive separation between the subwoofers.

A common mistake to make is assuming that by using a larger number of elements on either side this effect decreases, which is completely false, since the phase response is independent of the magnitude. In this case, the only difference is an increase of 6 dB every time we double the number of boxes, but lobes of pressure and corridors of cancellation will remain.

Therefore, if we maintain the separation over $\frac{2}{3}\lambda$, we will have the unintended effect of a comb filter, regardless of the number of elements used.



SPL MAP of two LYNX LX-218S separated 13 m. Horizontal view

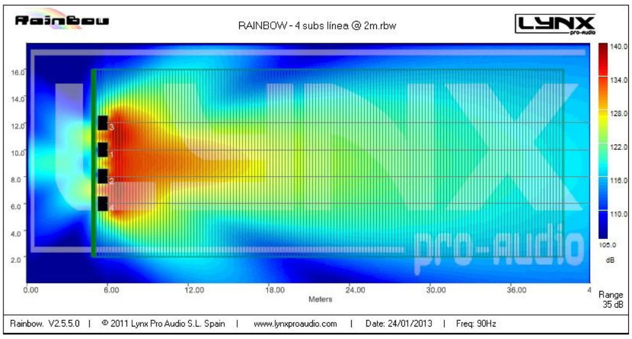


SPL MAP of 2+2 LYNX LX-218S separated 13 m. Horizontal view

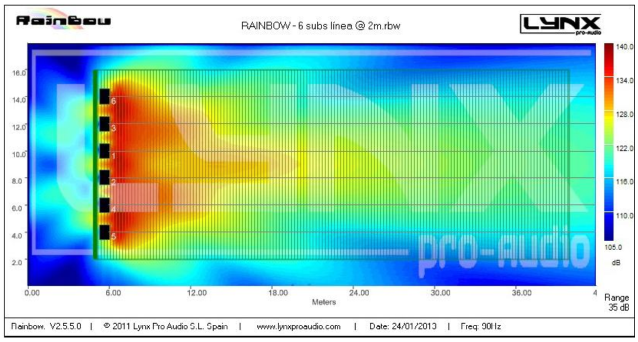
To prevent this from happening, we can perform an in-line configuration of the subwoofers.

IN-LINE CONFIGURATION OF THE SUBWOOFERS

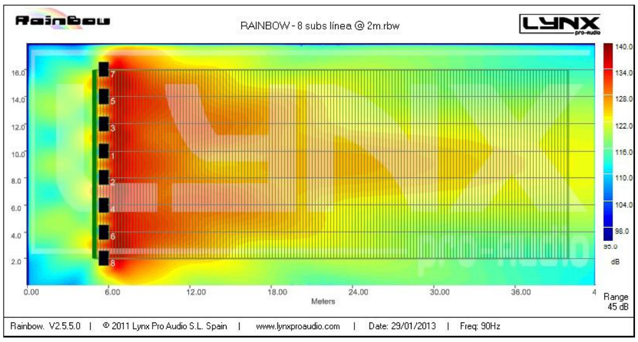
We can perform an in-line configuration of the subwoofers, which involves placing all the elements in a horizontal line, respecting the maximum separation of $\frac{2}{3}\lambda$ mentioned above, and using the same signal for all of them.



SPL MAP of four LYNX LX-218S at 90Hz in line.

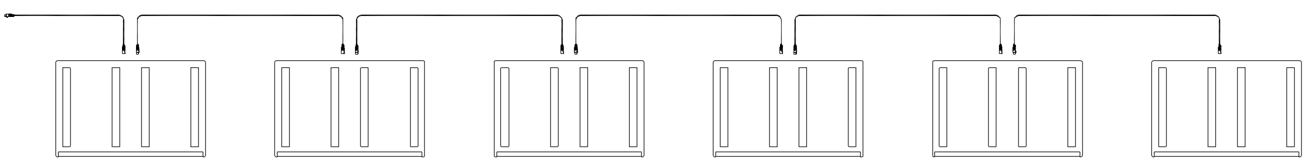


SPL MAP of six LYNX LX-218S at 90Hz in line.



SPL MAP of eight LYNX LX-218S at 90Hz in line.

In the pictures above three subwoofer configurations are shown in line with four, six and eight elements respectively. We can see how there are now no lobes of pressure or corridors of cancellation, maintaining a balance in the distribution of pressure in the area. The connection of the signal is performed as follows.



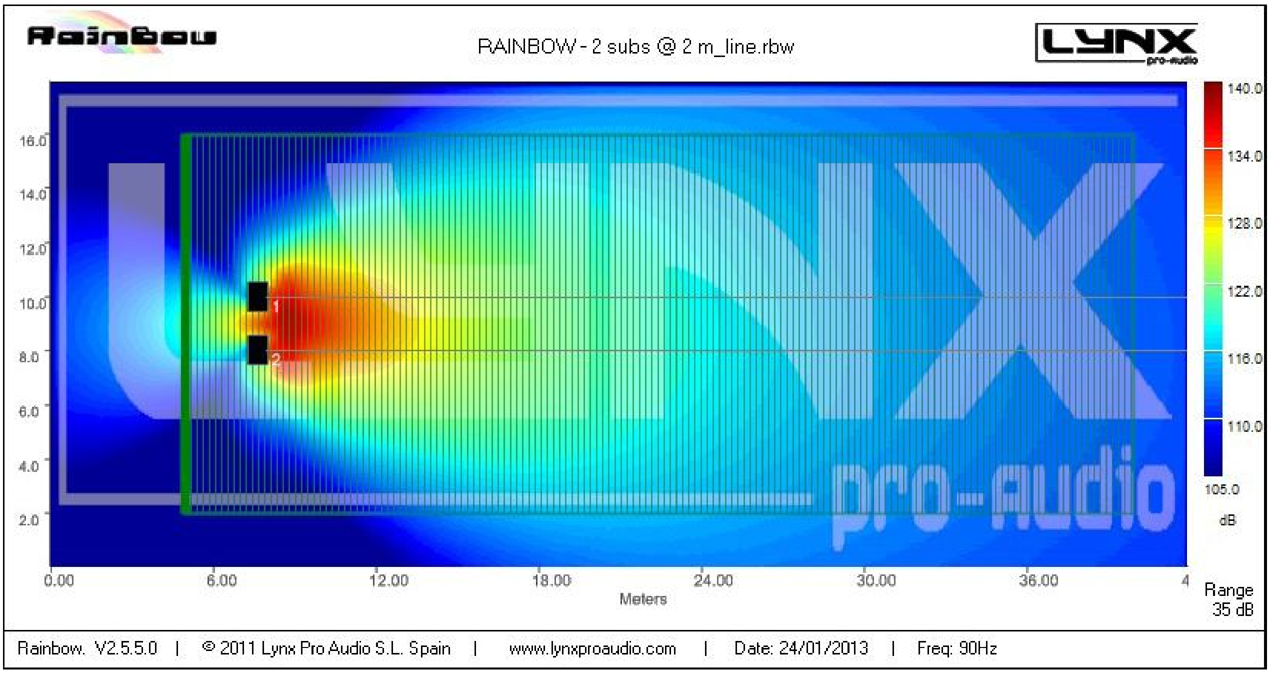
Connection drawing for six LYNX LX-218S with an in-line configuration.

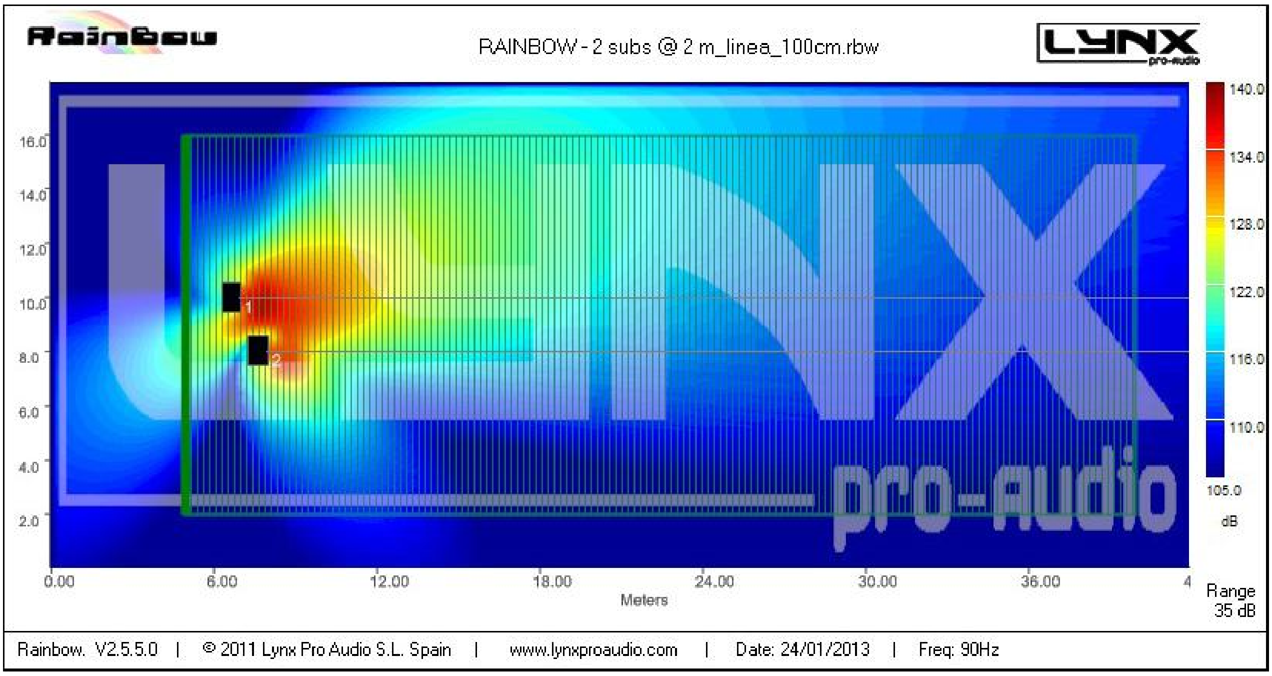
Although it would be much better to position the elements on one side and the other of the stage, you can also see that the coverage narrows as the distance increases. This effect could be minimized by using another technique, the arch arrangement.

THE ARCH ARRANGEMENT

In the separation of two subwoofers a central lobe of higher pressure always occurs. This effect could be minimized by using another technique, the arch arrangement.

In the pictures below we can see how to move one of these subwoofers back, being able to direct this lobe towards the east.





The arch arrangement technique consists of delaying the external elements from the interior from an in-line configuration, so that the pressure is equal in the front areas, avoiding coverage narrowing from the in-line arrangement. The connection is made in the same manner as in the in-line arrangement.

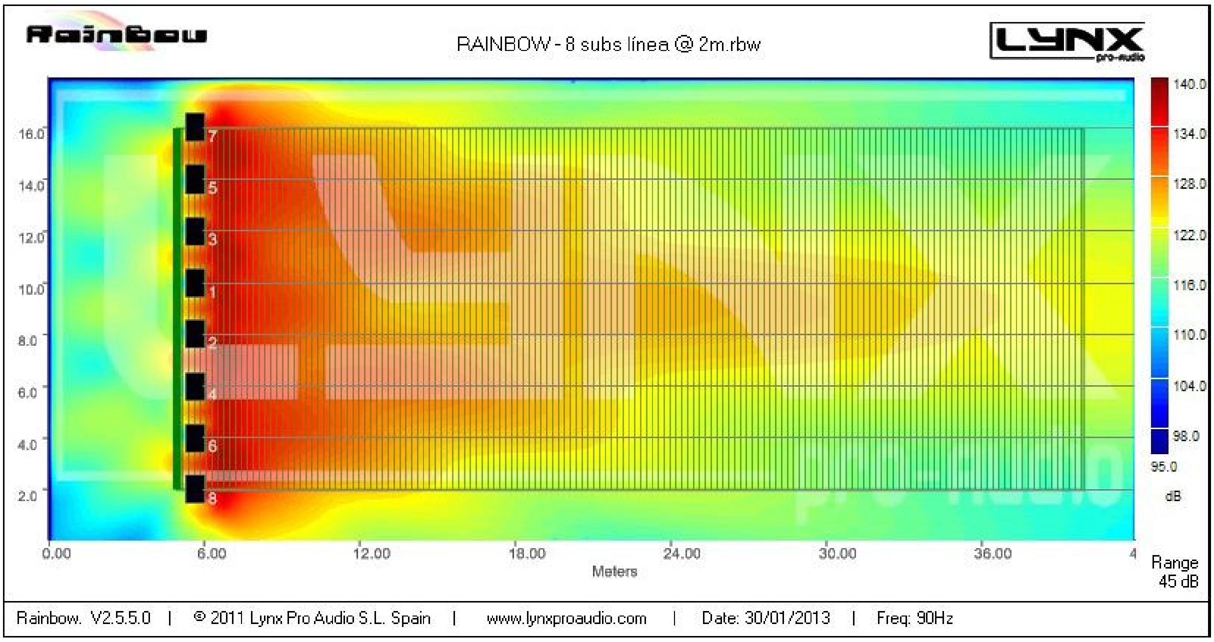


Fig. A

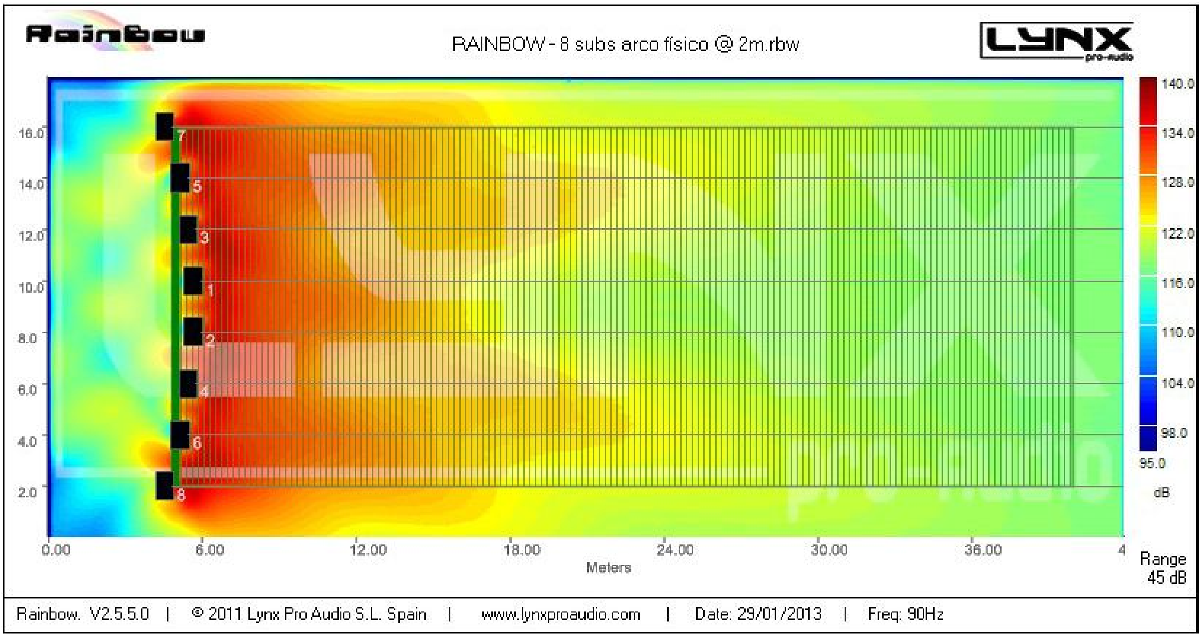
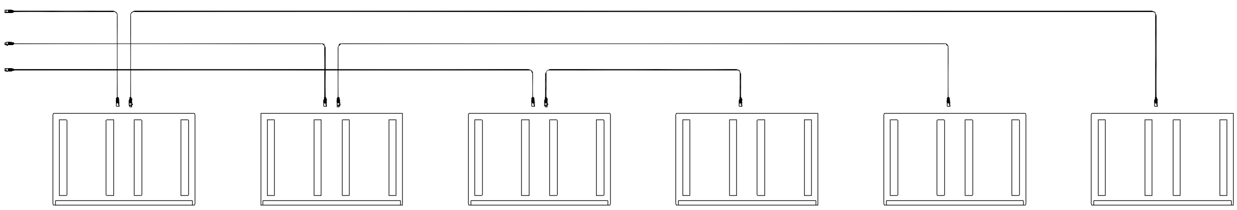


Fig. B

The above images show a pressure map of an in-line and an arch arrangement respectively, as well as seeing the elimination of the narrowing of the coverage at the front of the first, we can see how in the rear this narrows a little, so that the stage will have less low frequencies.

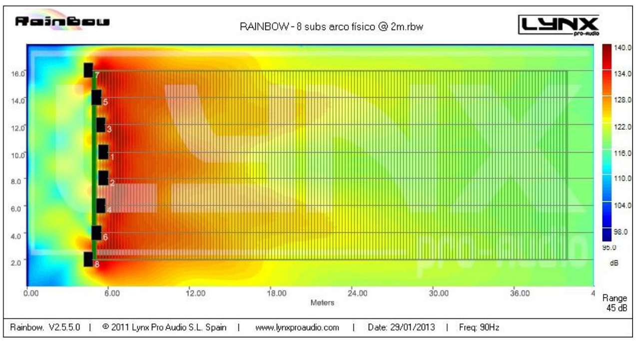
In many cases, it is impossible to position the subwoofer in an arch arrangement because of the space required, as there may be a change in position of about two meters from the front of the more advanced elements to the rear of the most backward. To solve this arrangement can be employed instead of electron beam of an array of physical arc. This involves placing the subwoofer online and applying delay to a signal processor at a rate of 2.92 ms per meter.

In Figure B we can see elements 1 and 2 (central) which are considered as references. They have not been delayed. Elements 3 and 4 (adjacent to the center) have been placed 0.2 meters back, equal to 0584 ms. Elements 5 and 6 have been placed 0.5 meters back, equal to 1.46 ms. And elements 7 and 8 (positioned on the outside), have been placed 1.1 meters back, equivalent to 3,212 ms. Therefore, we will need four channels of independent processing and can connect the signal as shown in the graph below.

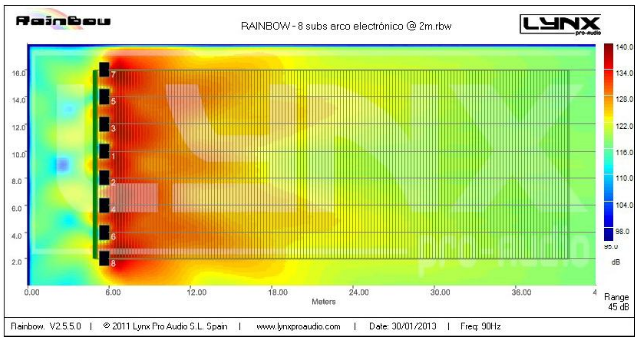


Connection drawing for an electronic arch placement of six LYNX LX-218S.

Comparing the pictures below, we can see how the configuration of physical arch and electronic arch are nearly identical, differing only in the rear, with the rear cover being narrower in the physical arch configuration.



Physical arch



Electronic arch