

Dolby® Atmos™

Cinema Technical Guidelines

Overview

Dolby® Atmos™ achieves unprecedented levels of audience immersion and engagement by offering powerful new authoring tools to mixers. Its new cinema processor features a flexible rendering engine that optimizes the audio quality and surround effects of the Dolby Atmos soundtrack to each room's loudspeaker layout and characteristics. In addition, Dolby Atmos has been designed from the ground up to maintain backward compatibility and minimize the impact on production, distribution, and exhibition workflows.

The introduction of a new audio format allows for changes in the design of sound systems without breaking compatibility with existing practices. Dolby has revisited critical areas of soundtrack reproduction, including equipment performance, layout, and installation for dubbing theaters and cinemas. This white paper describes how to equip auditoriums for Dolby Atmos playback.

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1 Introduction

1.1 Purpose and Scope

1.1.1 Purpose

This document is primarily intended to be a quick design reference for those involved in the planning of cinemas. Its aim is to help exhibitors determine where loudspeakers should be installed for the highest-quality Dolby Atmos reproduction.

1.1.2 Scope

Subjects pertaining to speaker placement and orientation are discussed with recommended design targets. Flexibility within these guidelines may be necessary to ensure that the Dolby Atmos playback is as universal and practical as possible. Final loudspeaker placement will depend on conditions such as the physical dimension of the auditorium, elevation change in the seating area, architectural and mechanical constraints of each auditorium, and mechanical design and performance of loudspeakers. Note that these guidelines contain a range of options, particularly with respect to placement of surround speakers.

These guidelines do not address auditorium design, image size, acoustics, loudspeaker mounting, safety, or other regulatory issues such as building and electrical codes.

2 Dolby Atmos System Design

2.1 Screen Loudspeakers

2.1.1 Placement and Elevation

The Center speaker should always be placed at the center line of the screen regardless of the position of the screen within an auditorium. In traditionally designed cinemas, the Left and Right screen speakers should be positioned midway between the 1.85:1 (flat) and 2.39:1 (scope) images, as illustrated in Figure 1. For those auditoriums in which the screen width is greater than 12 meters (40 ft), the addition of two additional screen loudspeakers can be beneficial in creating smoother pans across the screen. If installed, the Left Center (Lc) and Right Center (Rc) speakers should be placed midway between the Center speaker and the Left and Right speakers. It is recommended that all screen speakers be identical.

In traditionally designed auditoriums with fixed image height, the screen speakers should be positioned vertically so that the acoustic center elevation is approximately two-thirds of the screen height.

The acoustic center will vary with speaker design type, but it is typically located at the midpoint of the horn for a two-way screen speaker or just between the middle- and high-frequency horns for a three-way screen loudspeaker system.

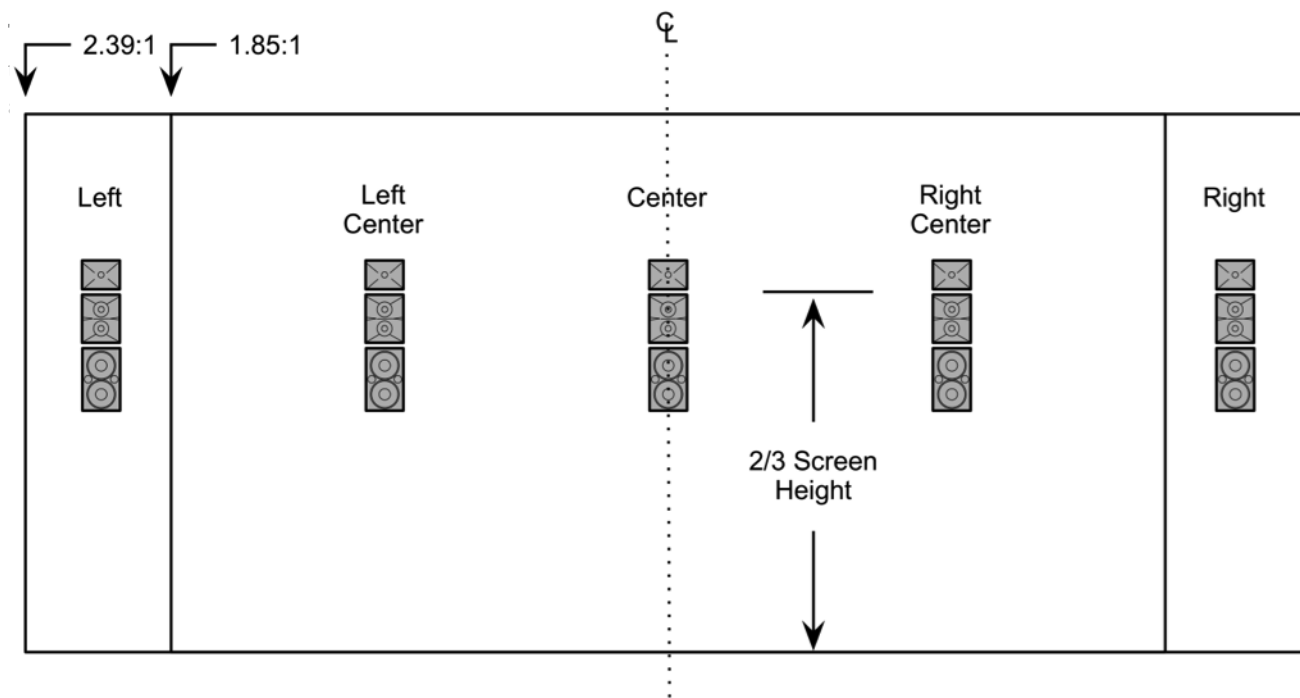


Figure 1. Placement of Screen Speakers in Traditionally Designed Cinemas

In auditoriums with fixed image width and top moving masking, the Left and Right screen speakers should be placed just at the inside edge of the image. Due to the variable height, a compromise must be made for the vertical position. Dolby recommends positioning the acoustic center midway between two-thirds of the screen height for the flat and scope images, as illustrated in Figure 2.

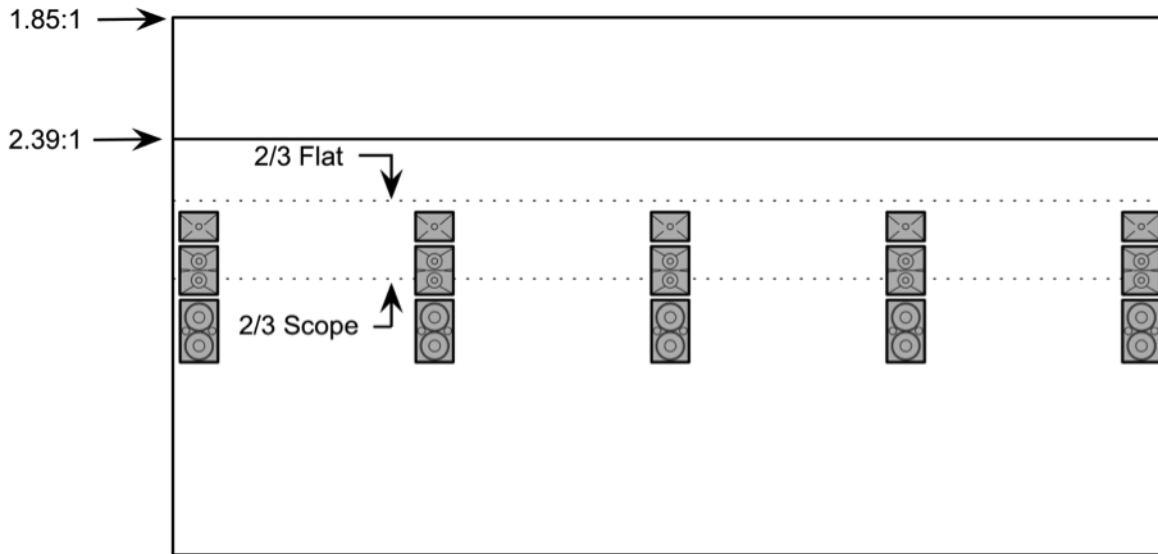


Figure 2. Placement of Screen Speakers in Cinemas with Fixed Image Width and Top Moving Masking

2.1.1.2 Aiming

The screen speakers should be rotated horizontally so the axis of the speaker is oriented at a point two-thirds back in the auditorium along the center line of the image. Only the horns should be rotated horizontally for speakers mounted in a 2π wall (baffle wall), keeping the woofers flush with the wall.

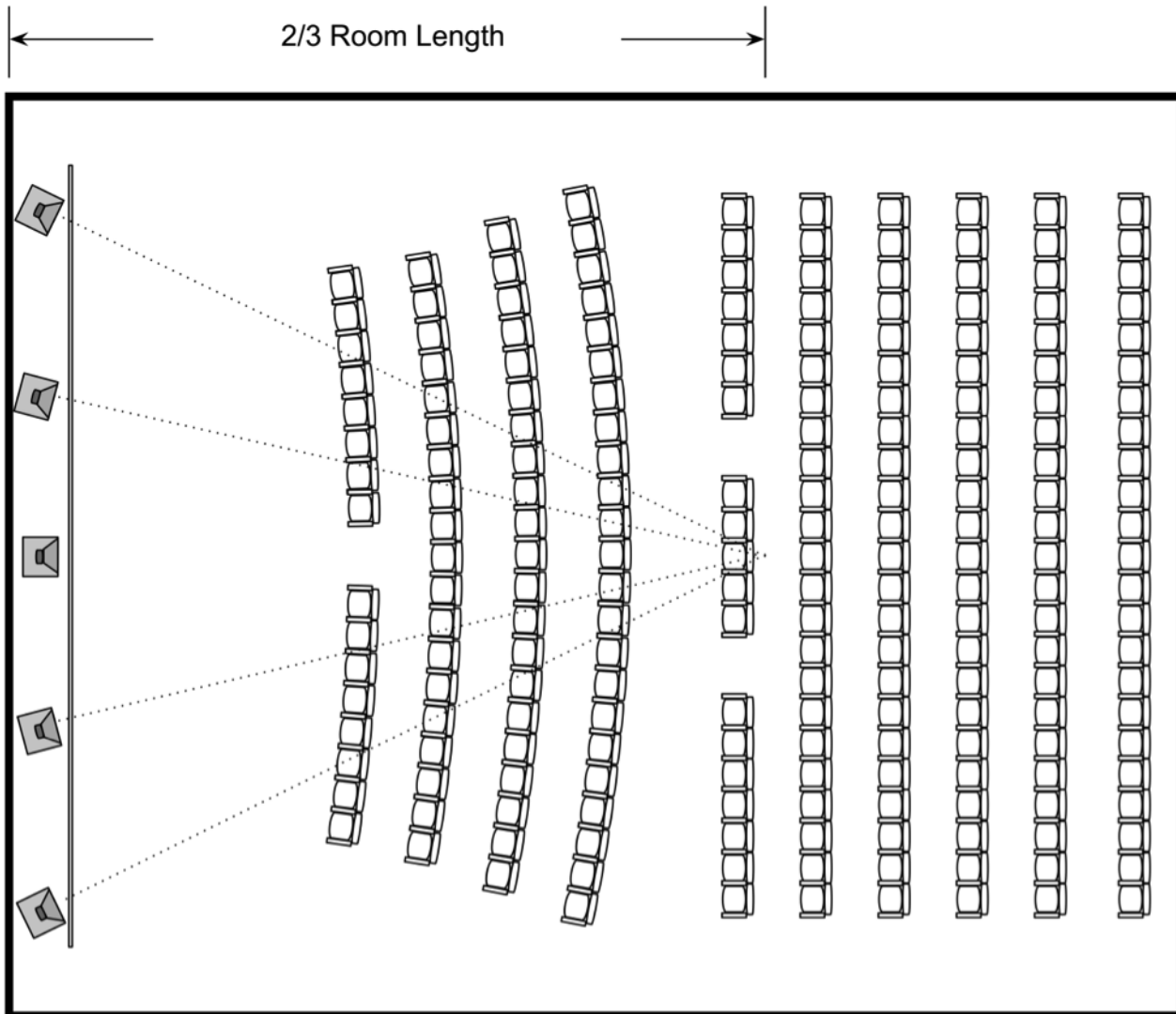


Figure 3. Rotation of Screen Speakers

The screen speaker horns should be oriented to provide the best coverage over the seating area. A number of factors will affect coverage, including the vertical dispersion characteristics of the speaker, speaker elevation, length of the auditorium, and change in elevation over the seating area. Refer to the speaker manufacturer's literature to determine the downward elevation angle that will yield the best coverage for your auditorium.

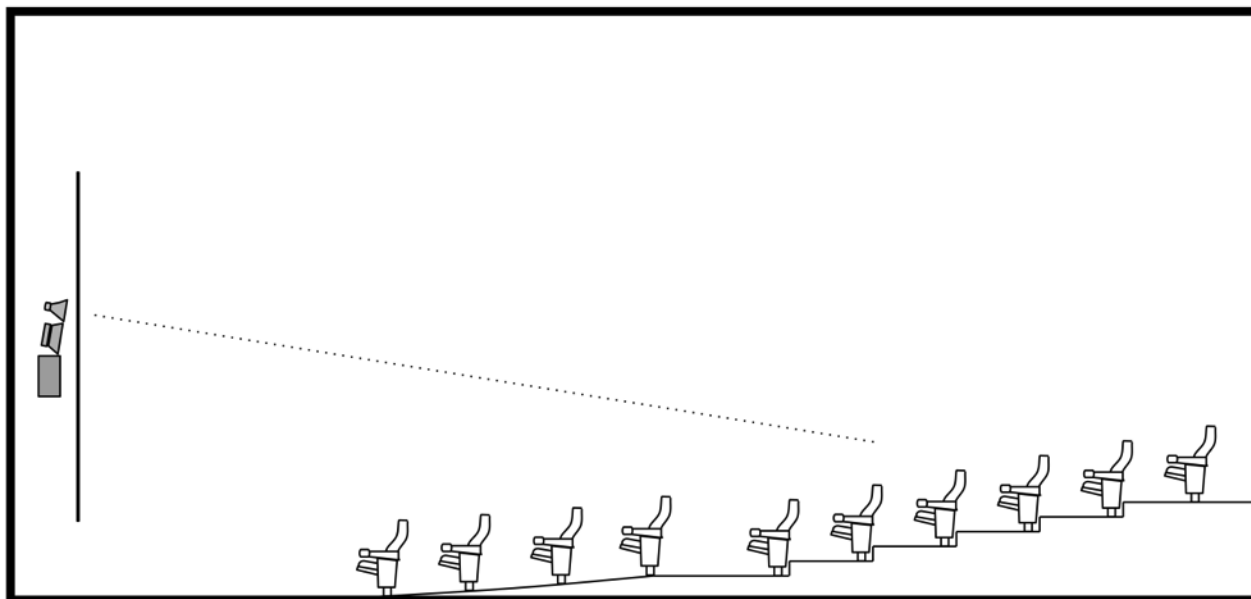


Figure 4. Rotation of Screen Speaker Horns

2.1.3 Screen Subwoofers

Subwoofers, for low-frequency effects (LFE), should be placed on the floor behind the screen, at the rear wall junction, or flush-mounted in a screen wall. When multiple subwoofers are used, Dolby recommends they be clustered together to increase the effective efficiency through mutual coupling. The subwoofer cluster should be placed asymmetrically with respect to the center of the room to minimize stimulation of standing waves (room modes).

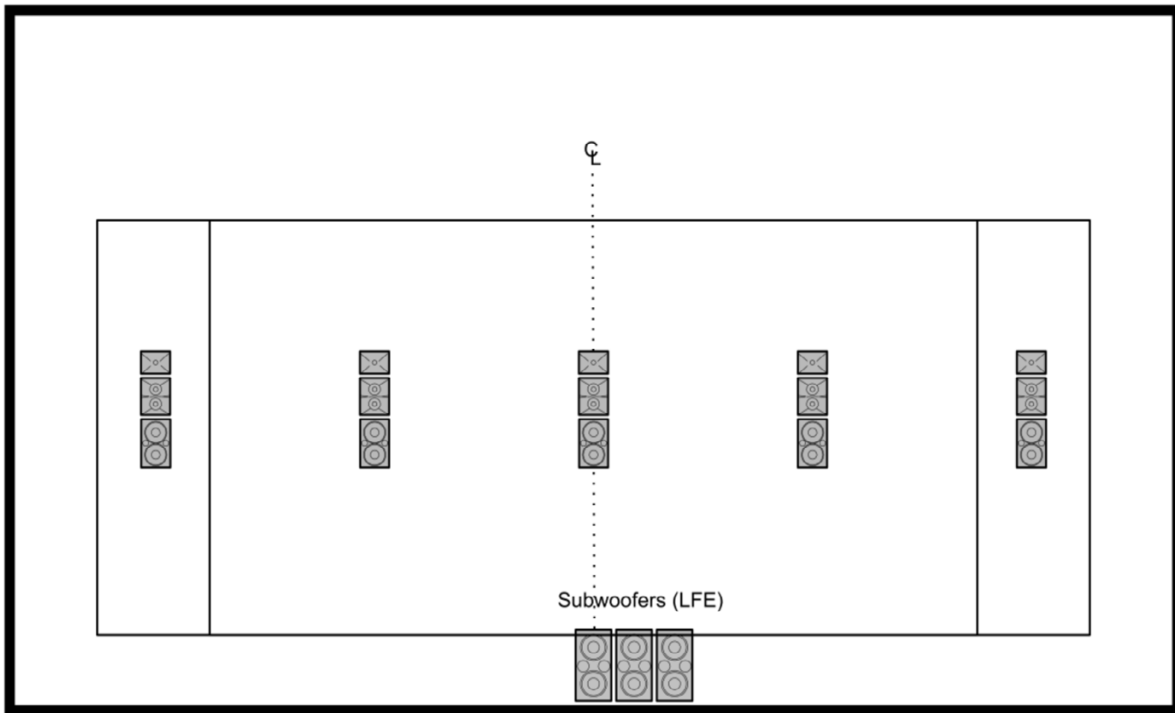


Figure 5. Placement of Screen Subwoofers

2.2 Surround Loudspeakers

2.2.1 Additional Surrounds

One of the main differences between Dolby Atmos and Dolby Surround 7.1 or 5.1 is the position of surround speakers. Dolby Atmos provides the ability to precisely position sound from anywhere in an auditorium. To accomplish this, additional surround speakers are added to the sidewalls and ceiling. Side surround arrays should extend closer to the screen than previous recommended practices of loudspeaker placement, starting at one-third the distance to the back of the auditorium. Top surround speakers are mounted as illustrated in Figure 6 and as described in the Top Surround Placement and Top Surround Aiming sections of this document.

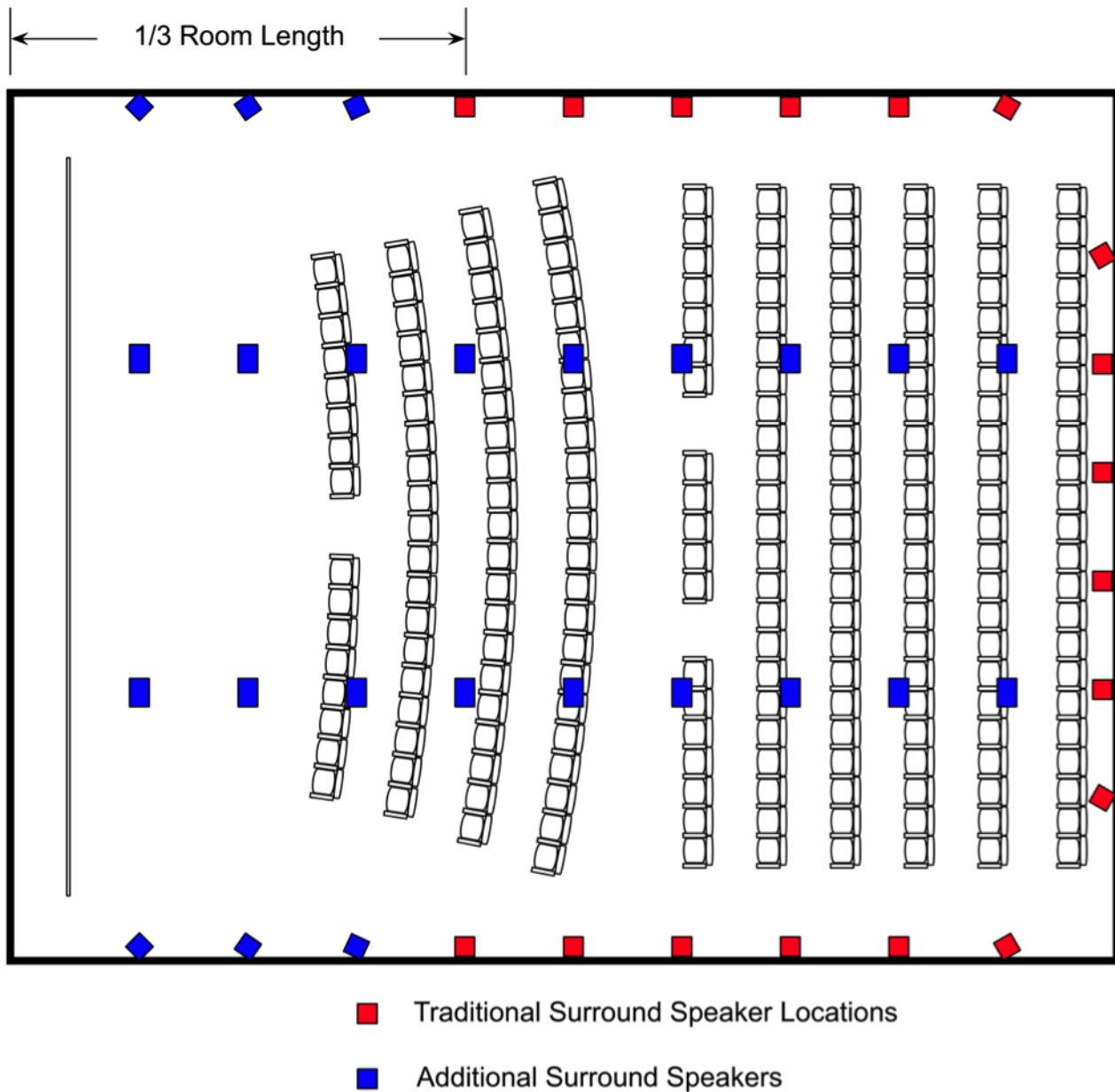


Figure 6. Placement of Surround Speakers for Dolby Atmos

2.2.2 Side and Rear Surround Spacing

As a rule of thumb for an average-sized theater, the spacing of surround speakers should be between 2 and 3 meters (6'6" and 9'9"), with Left and Right Surround speakers placed symmetrically. However, the spacing of surround speakers is most effectively considered in terms of angles subtended from a given listener between adjacent loudspeakers, as opposed to absolute distances between loudspeakers.

For optimal spatial resolution throughout the auditorium, the angular distance between adjacent loudspeakers should be 30 degrees or less, referenced from the midpoint between two loudspeakers at the edge of the central listening area. The central listening area is defined as those seats more than one-quarter room-width from the nearest wall, as represented in grey in Figure 7. Loudspeaker spacing adjacent to the seating area should remain linear where possible. The surround speaker spacing beyond the listening area, for example, between the front row and the screen or in the rear corners, can be slightly wider. If using surround speakers with limited output power capability, more speakers may be required to meet sound pressure level requirements.

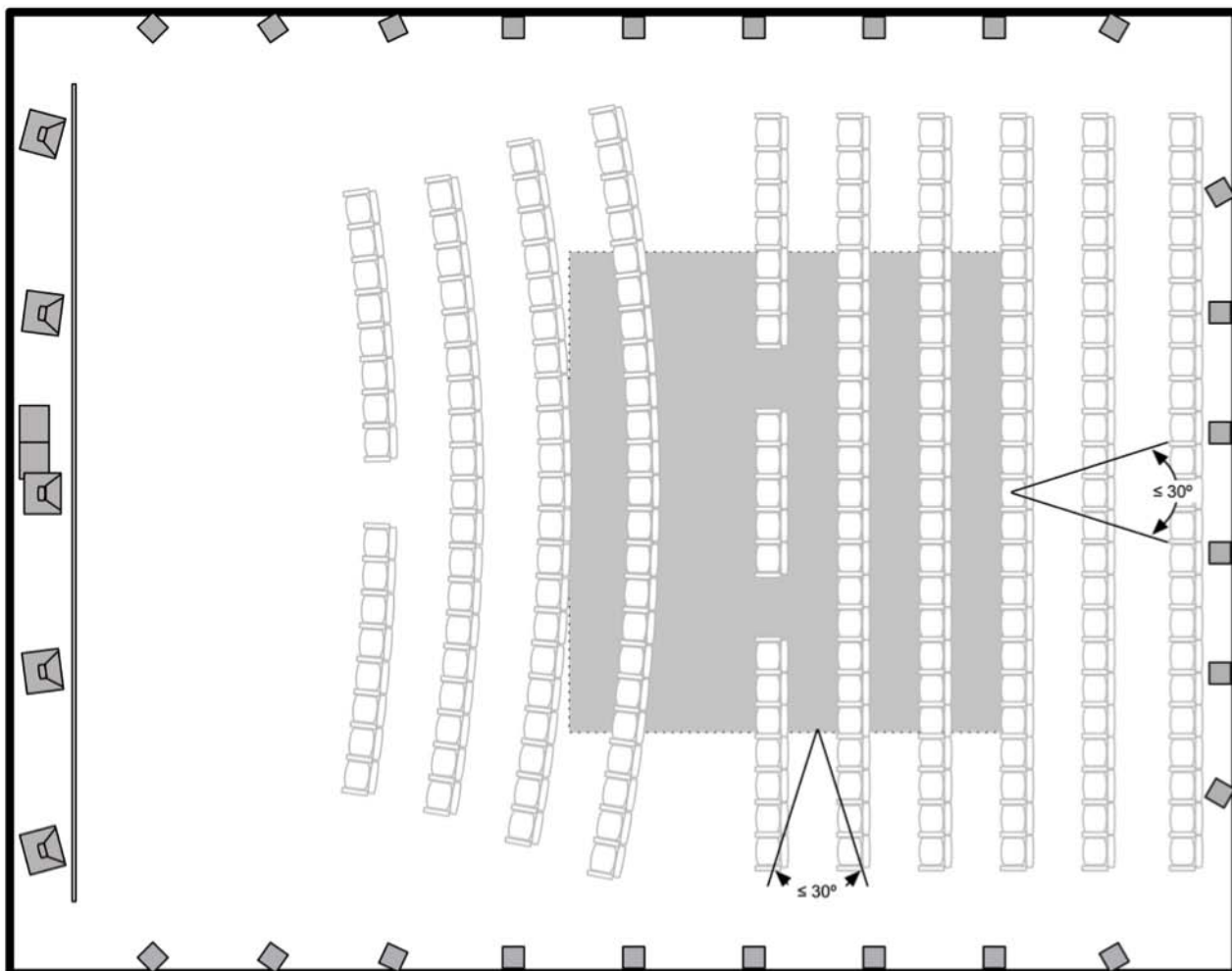


Figure 7. Prime Listening Area and Angular Distance Between Adjacent Speakers

2.2.3 Side and Rear Surround Elevation

The side and rear surround speakers should be mounted subject to the following constraints:

- The elevation of the surround speaker closest to the screen should match the elevation of the acoustic center of the screen speaker.
- The elevation for the speakers along the rear wall should:
 - Be consistent with the relative elevation of the surround closest to the screen—as the seating elevation increases toward the rear of the auditorium, the surround speaker elevation should similarly increase.
 - Be out of the reach of patrons, where possible, to prevent damage, theft, and so on.
 - Be sufficiently high to maintain good coverage across the seating area according to the directivity of the speaker. One-quarter room-width is a good guideline.
- The vertical placement of the side surround speakers should form a straight line from the speaker closest to the screen to the speakers along the rear wall of the auditorium.

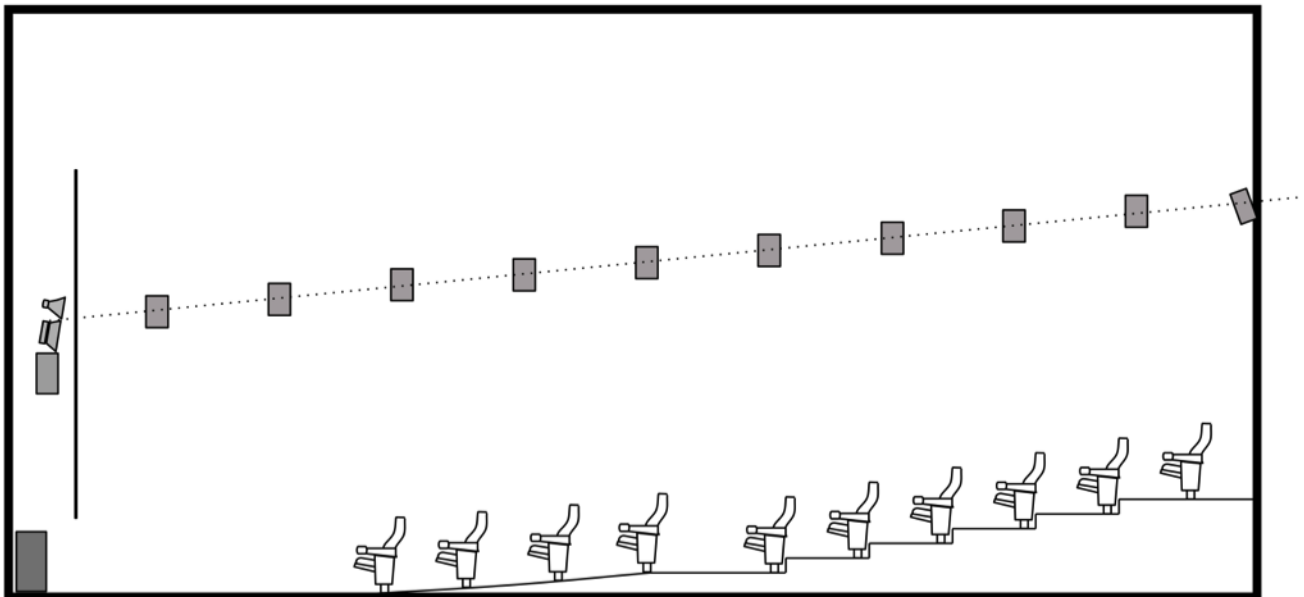


Figure 8. Elevation of Side and Rear Surround Speakers

2.2.4 Side and Rear Surround Aiming

Side surround speakers should be tilted to orient the axis of each speaker to the seated ear height of a listener in the farthest seat at the opposite side of the room, as illustrated in Figure 9.

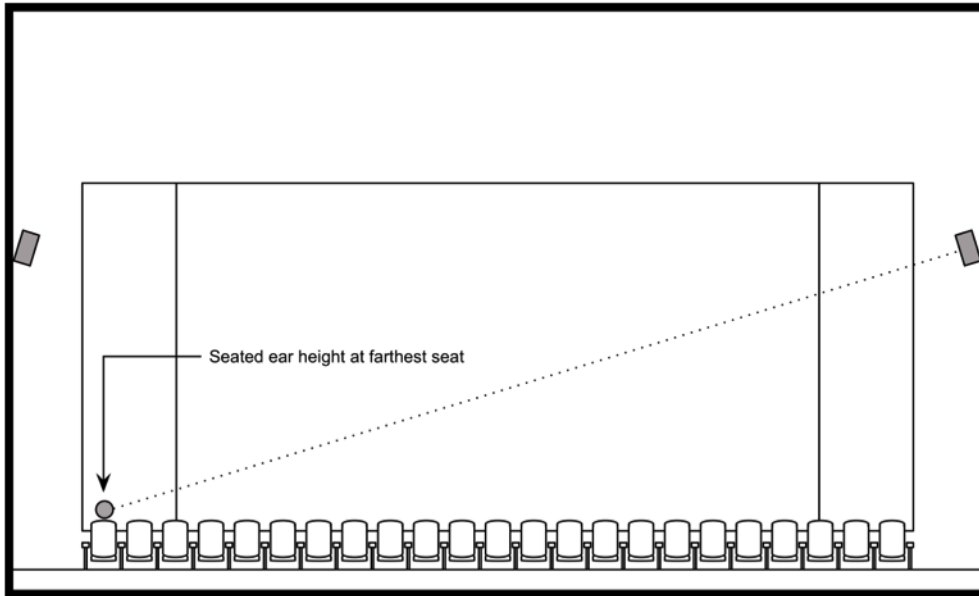


Figure 9. Aiming of Side Surround Speakers

Rear surround speakers should be tilted to orient the axis of each loudspeaker to the seated ear height of a listener in the front row, as illustrated in Figure 10.

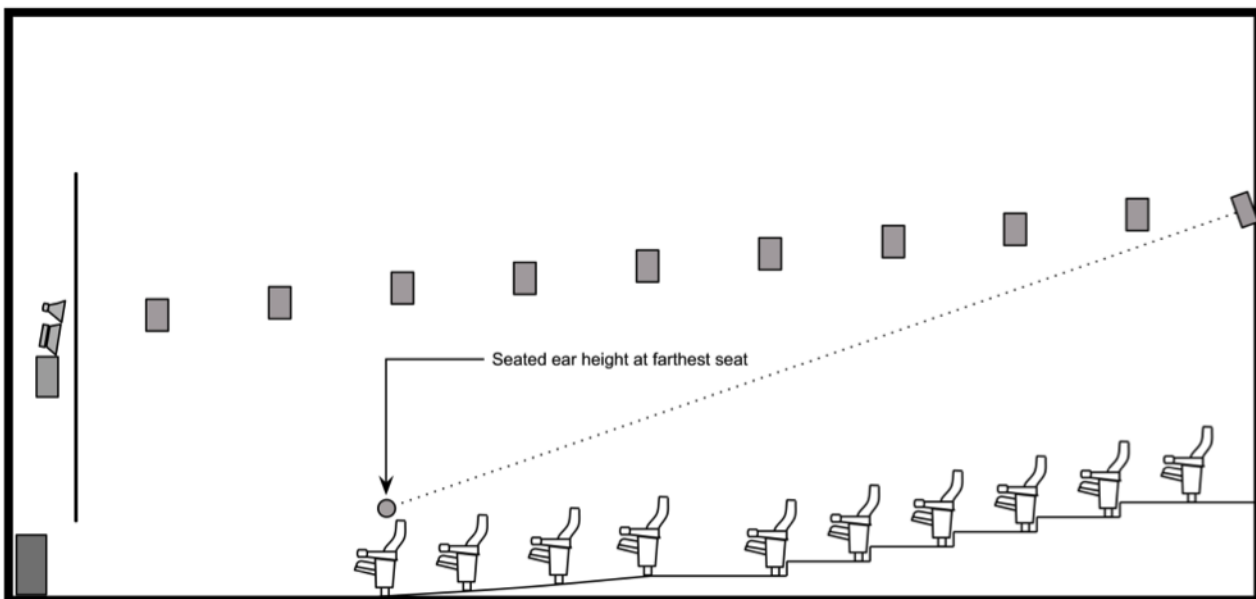


Figure 10. Aiming of Rear Surround Speakers

Side surround speakers in front of the seating area and surround speakers in the rear corners of the auditorium should be angled horizontally toward the center of the seating area, subject to the following constraints:

- The horizontal rotation of any speaker should not exceed 45 degrees.
- The axis of the side surround speakers positioned along the main portion of the seating area should be perpendicular to the lengthwise center line of the room.
- The axis of the rear surround speakers positioned along the main portion of the seating area should be parallel to the lengthwise center line of the the room.

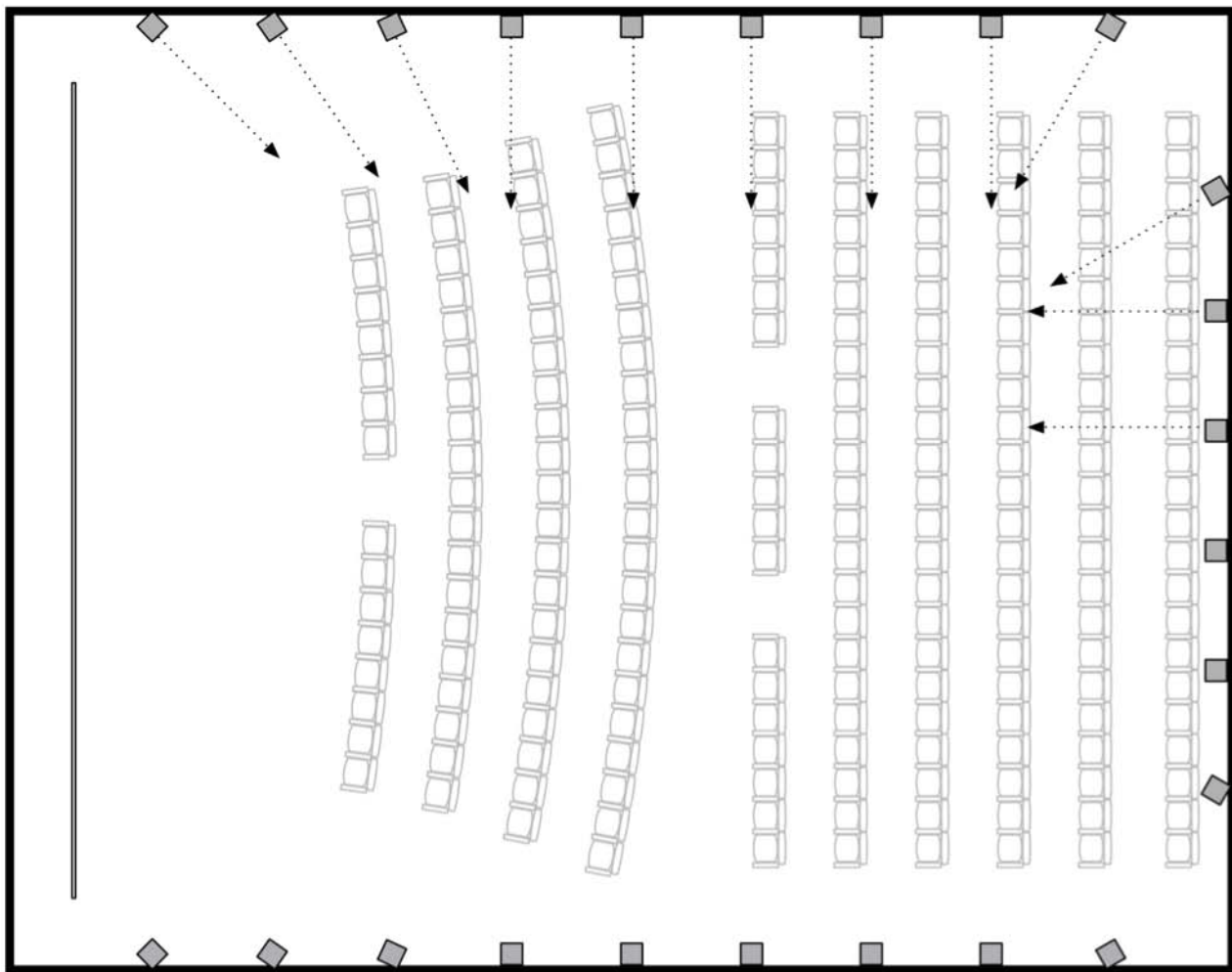


Figure 11. Angling of Side Surround Speakers

2.2.5 Top Surround Placement

Overhead speakers should be installed in two arrays from the screen to the back wall, nominally in alignment with the Lc and Rc screen channels for a typical auditorium. Overhead speakers should always be placed symmetrically with respect to the center of the screen. The overhead speakers should have the same design characteristics as the side and rear surround speakers for consistent matching of timbre.

The number and spacing of the top surround speakers should be based on the position of the side surround speakers. It is important to ensure that the projection light path is not obstructed by one or more of the top surround speakers.

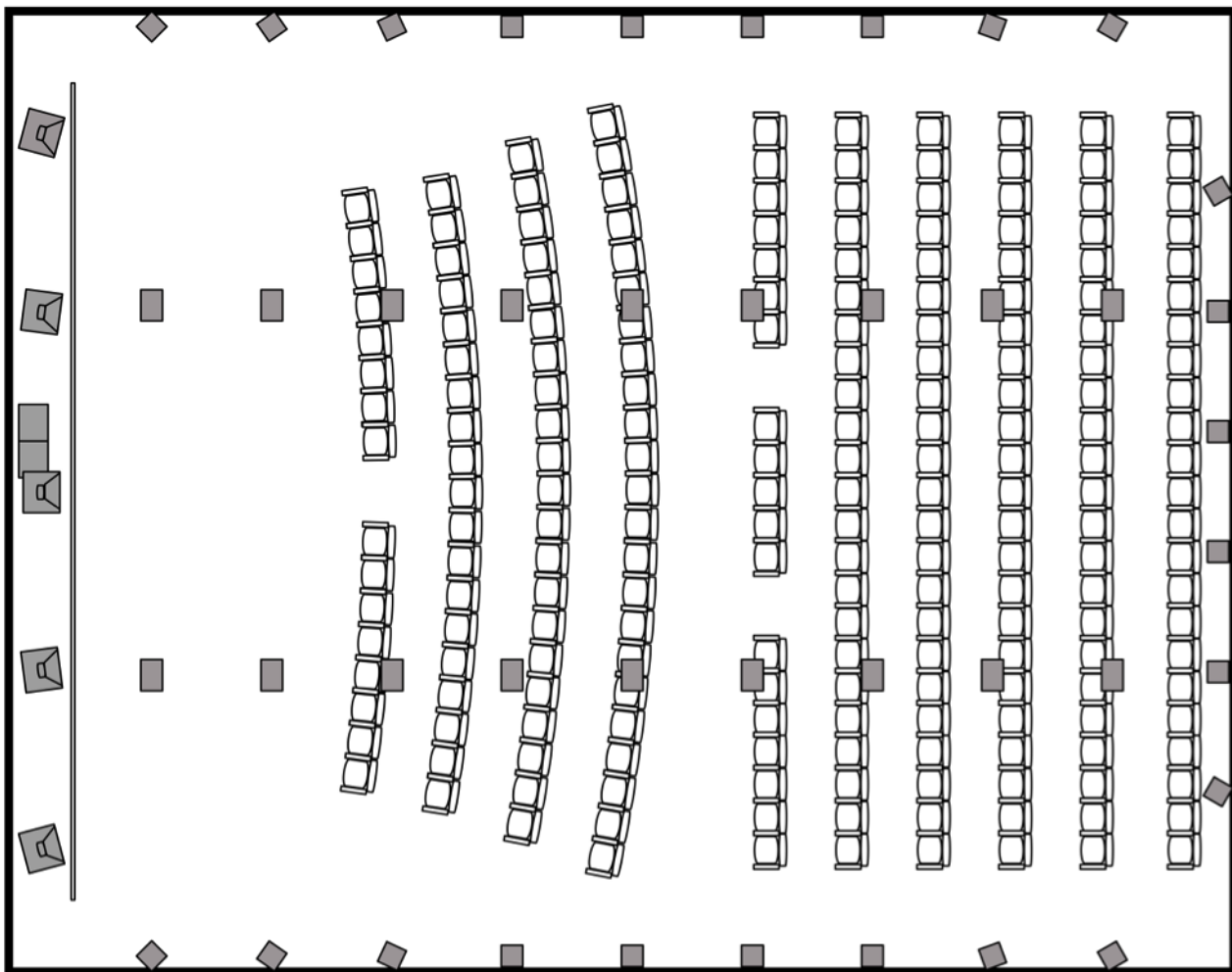


Figure 12. Placement of Top Surround Speakers

The lateral position of the arrays should be chosen to optimize spatial immersion and uniformity across the listening area. As stated earlier, placing the top surround speaker arrays in alignment with Lc and Rc screen channels will generally produce good results. For rooms in which the seating area is significantly wider than the

screen, or the top surrounds are mounted significantly higher than the level of the top of the screen, it is desirable to have the overhead arrays more widely spaced. The minimum width for spacing of top surround speakers conforms to the spacing of the Lc and Rc screen speakers. The maximum width between top surround speakers should be determined based on elevation angles as follows.

Let E be the elevation angle of the nearest side surround measured from the reference position, a point two-thirds back in the auditorium in the middle of the seating area. The elevation angle of the corresponding top surround array should be greater than or equal to 45 degrees plus half of angle E , as shown in Figure 13. For example, if E is 20 degrees, then the elevation angle of the top surround array should be greater than or equal to 55 degrees.

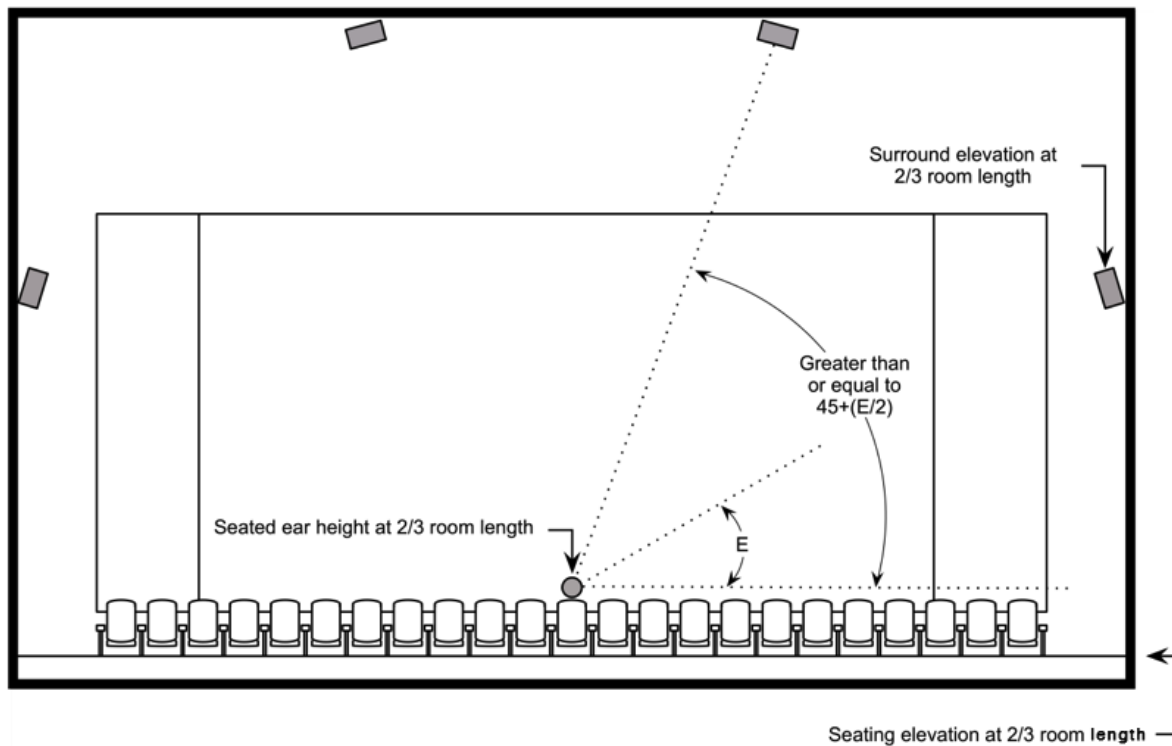


Figure 13. Maximum Width Between Top Surround Speakers

2.2.6 Top Surround Aiming

In order to provide optimum coverage, the top surround speakers should be angled laterally (across the auditorium) to a position halfway between the overhead speaker's lateral position and the center line of the auditorium, as illustrated in Figure 14.

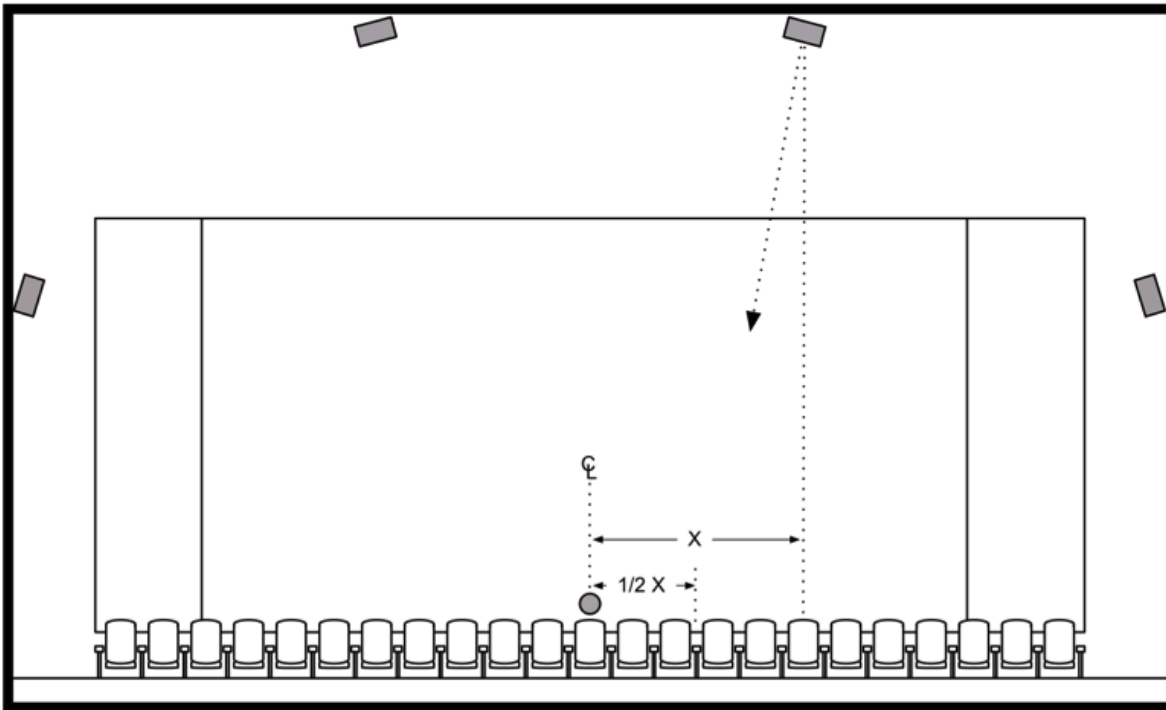


Figure 14. Lateral Angle of Top Surround Speakers

Top surrounds should be angled longitudinally (along the length of the auditorium) in the same manner as the side surrounds (see Figure 15). Taking 0 degrees as aiming vertically downward:

- No speaker angle should exceed 45 degrees.
- Speakers adjacent to the front and rear of the seating area should not exceed 30 degrees.
- Speakers over the central listening area should be left at 0 degrees.

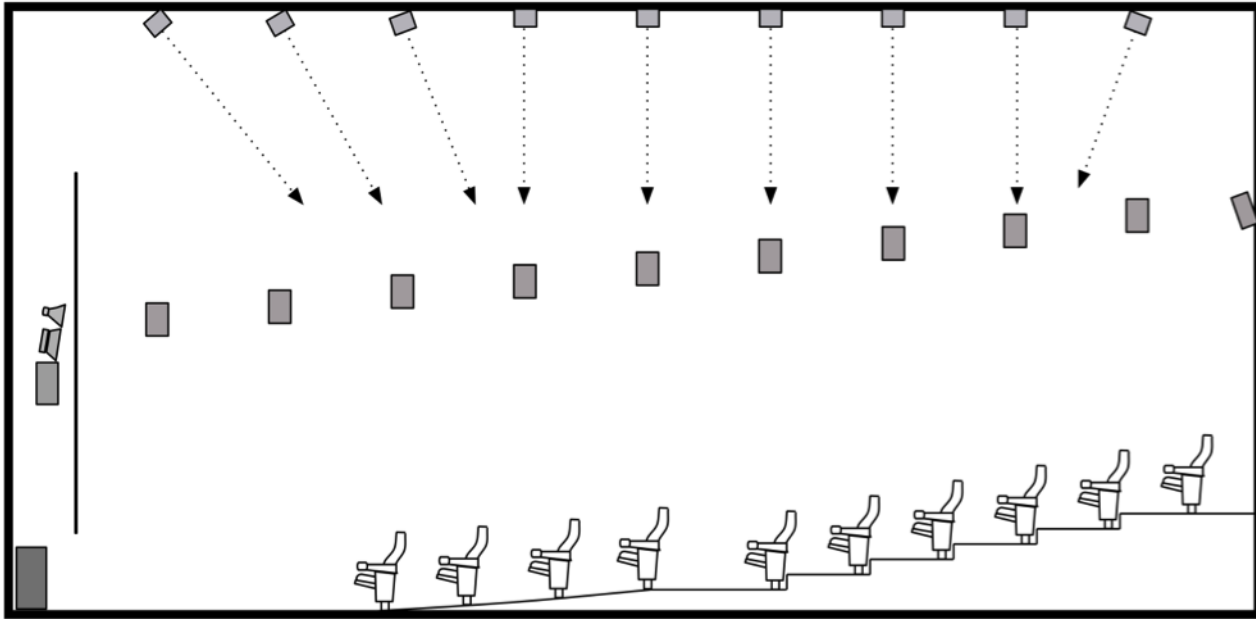


Figure 15. Longitudinal Angle of Top Surround Speakers

2.2.7 Surround Speaker Wiring

All surround speakers should be individually wired back to the location of the amplifiers and individually powered such that one speaker is directly connected to one channel of amplification.

2.3 Surround Subwoofers

The timbral consistency of objects panned from the screen speakers to surround zones is improved when bass performance remains consistent from speaker to speaker. However, surround speakers are typically not designed for the reproduction of frequency much below 100 Hz. Dolby has found that the low-frequency performance for surround speakers can be improved by using bass management to redirect the bass information from surround feeds to stereo subwoofers at the back of the room. Bass information from surround zones in the left half of the room is redirected toward one or more subwoofers in the rear left of the auditorium; likewise, bass information from surround zones in the right half of the room is redirected toward one or more subwoofers in the rear right of the auditorium (see Figure 16). The following guidelines pertain to placement of surround subwoofers in auditoriums:

- Locate subwoofers in the back third of the auditorium along the sidewalls, rear wall, or ceiling.
- Provide sufficient separation between the subwoofer(s) for the left surround zones and subwoofer(s) for the right surround zones.
- Avoid placing subwoofers in the rear corner of the auditorium—this will prevent maximum excitation of room modes. The minimum distance from a surround subwoofer to the rear corner should be approximately one meter.

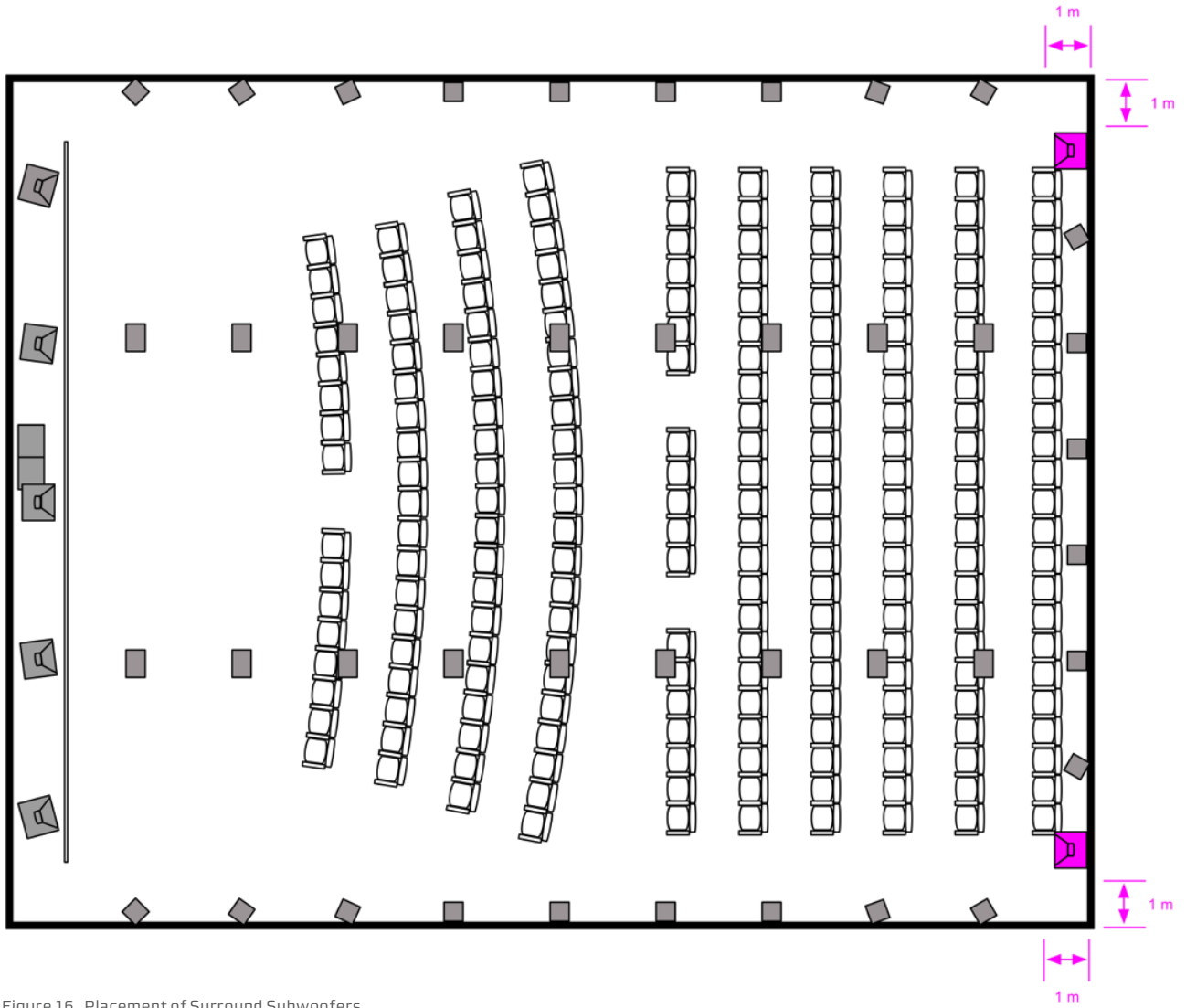


Figure 16. Placement of Surround Subwoofers



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