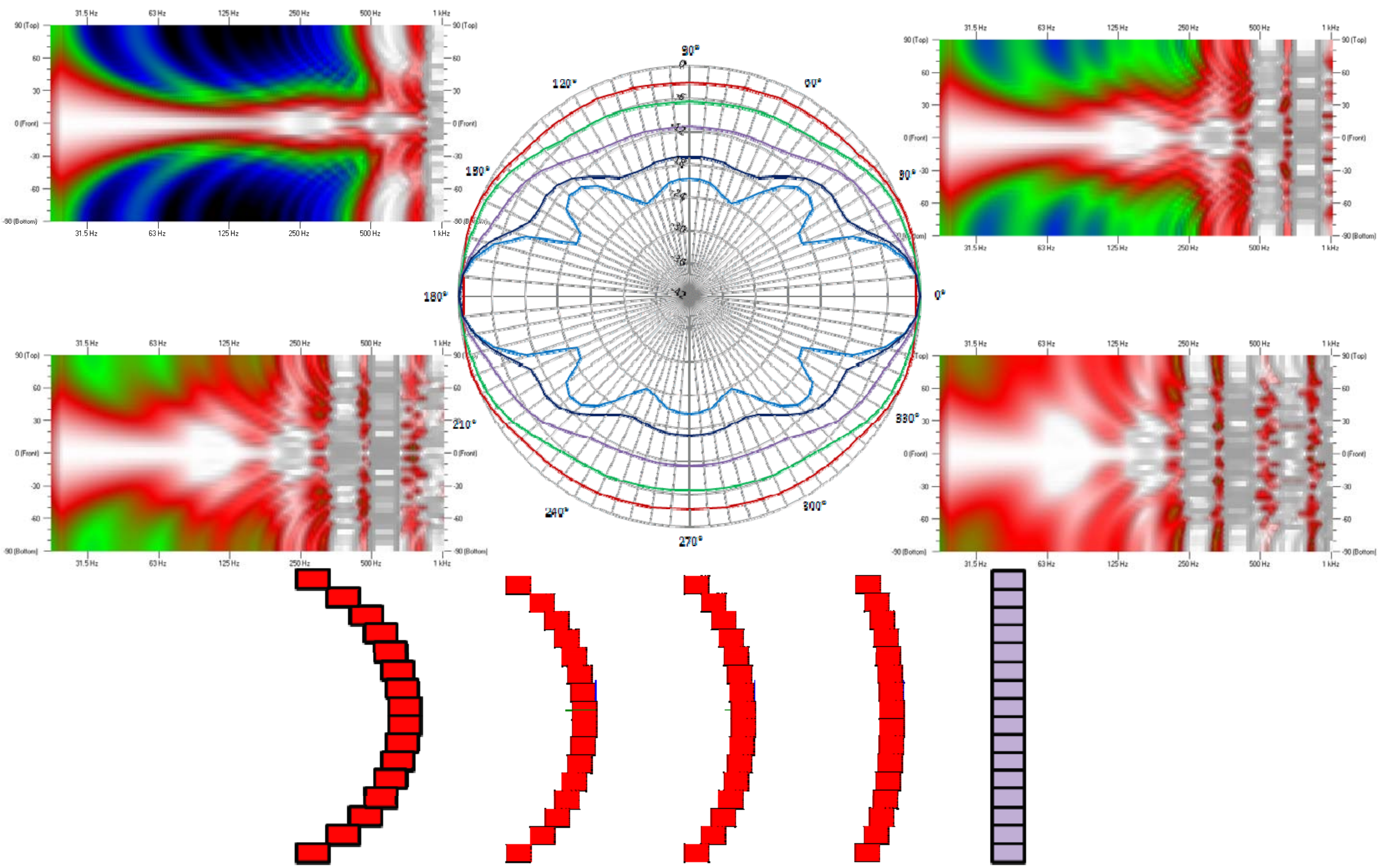
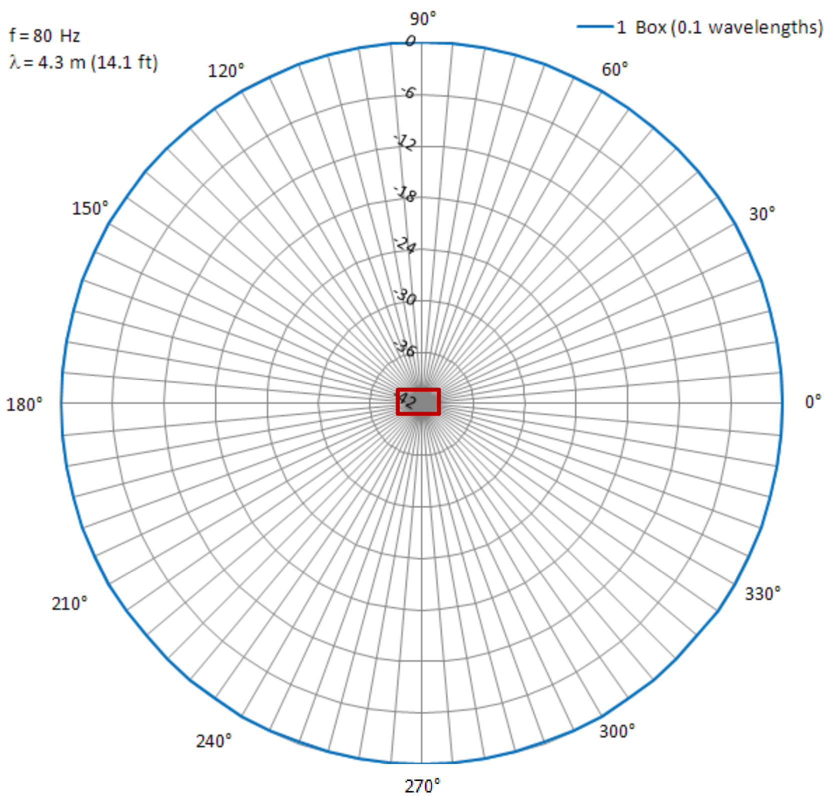
# Subwoofer Array Directivity



# Directivity as a Result Source Size




80 Hz polar graph of dual 18" subwoofer

The acoustical size of a source, or array, is relative to the wavelength which it is radiating.

A source is acoustically small when its is smaller than a given wavelength.

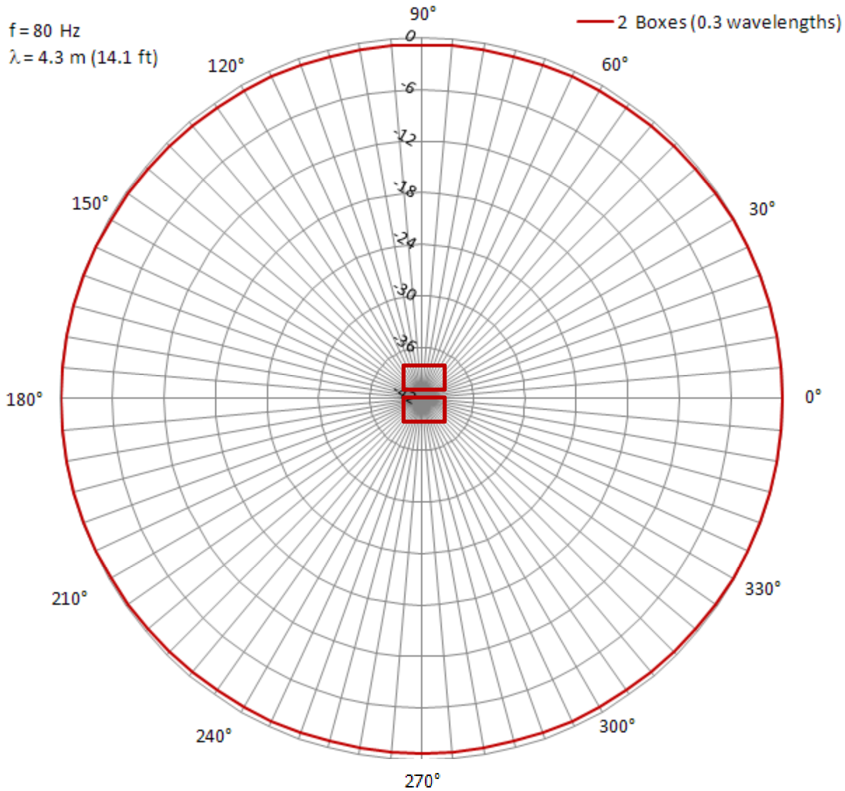
A source is acoustically large when it is approximately the same size or larger than a given wavelength.

Higher frequency, shorter wavelength

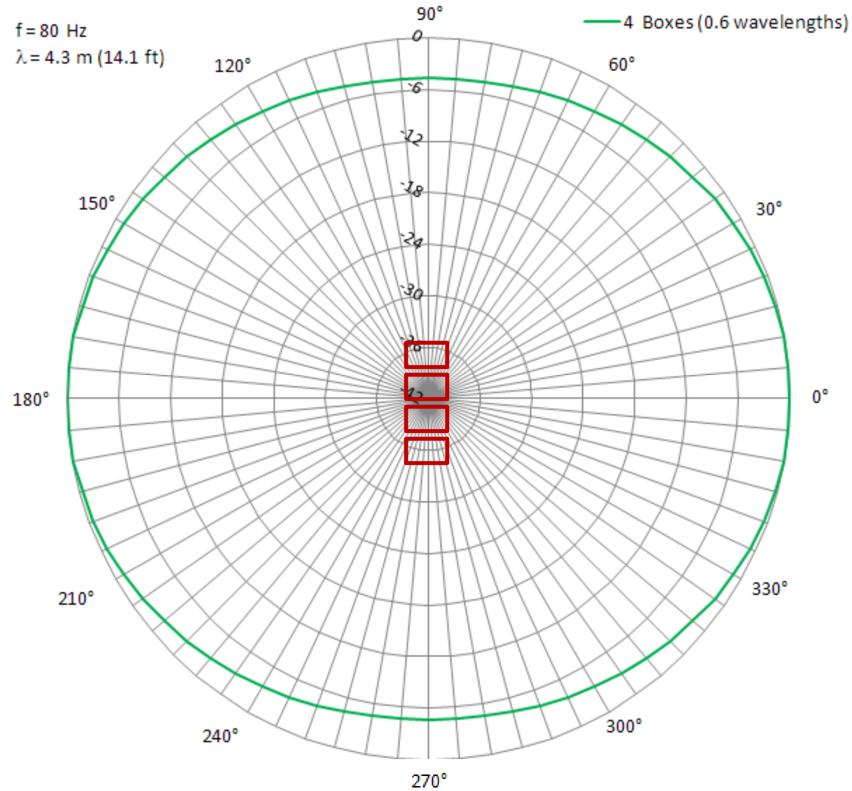
Lower frequency, longer wavelength

The dimension of the subwoofer is approximately 0.6 m (2 ft). This about 1/7 of a wavelength at 80 Hz. No directivity control.

# Directivity as a Result of Source Size



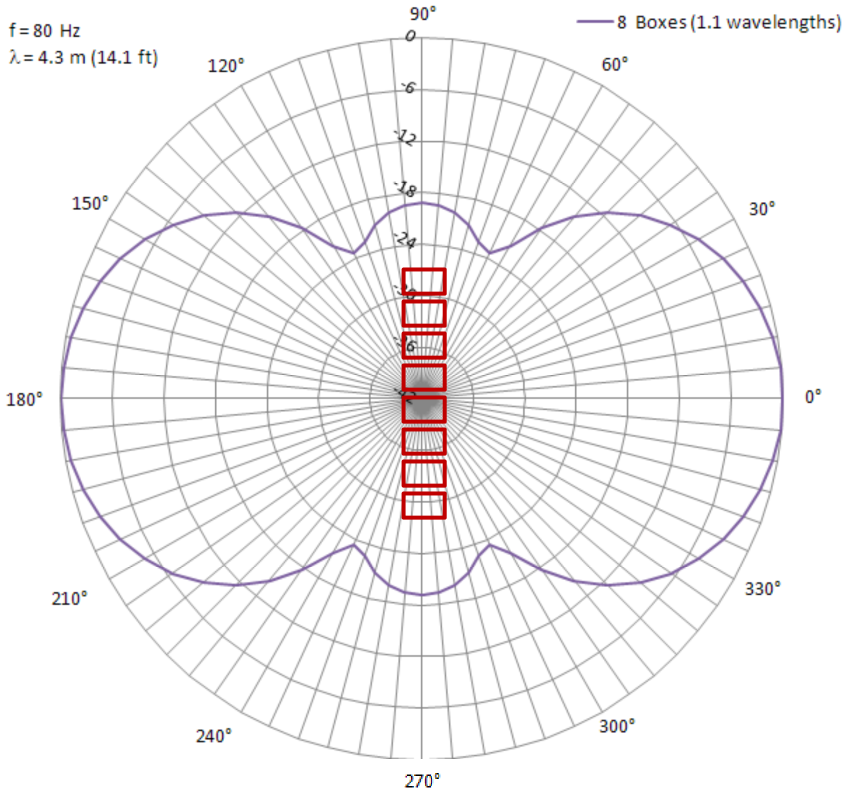

80 Hz polar graph of 2x dual 18" subwoofers



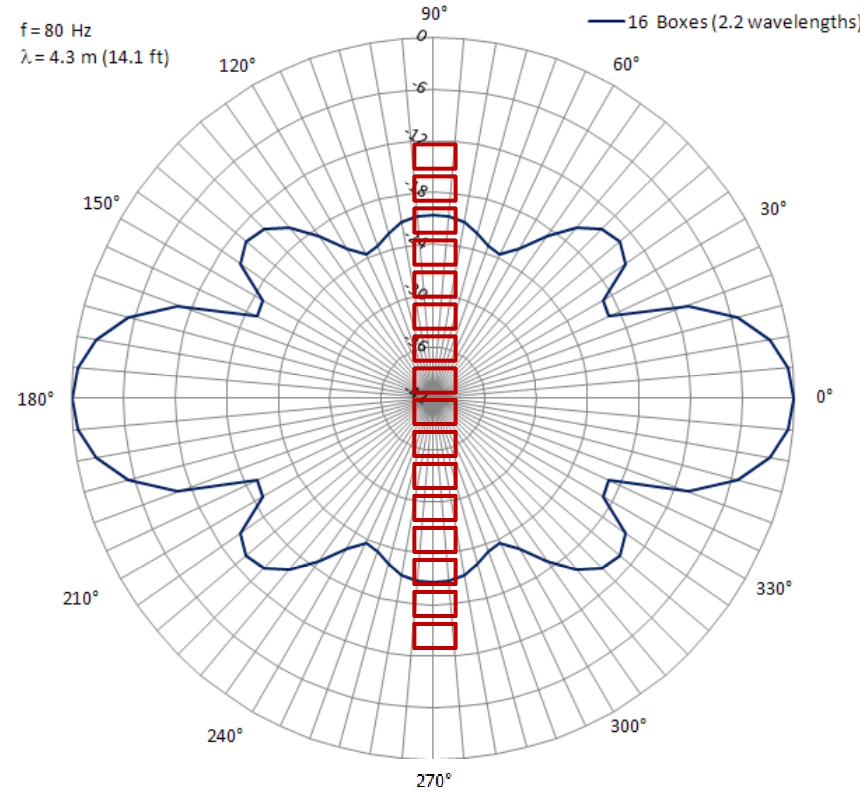

80 Hz polar graph of 4x dual 18" subwoofers

As the size of the array increases in a particular dimension, so does the directivity control in the plane of that dimension.

# Directivity as a Result of Source Size




80 Hz polar graph of 8x dual 18” subwoofers

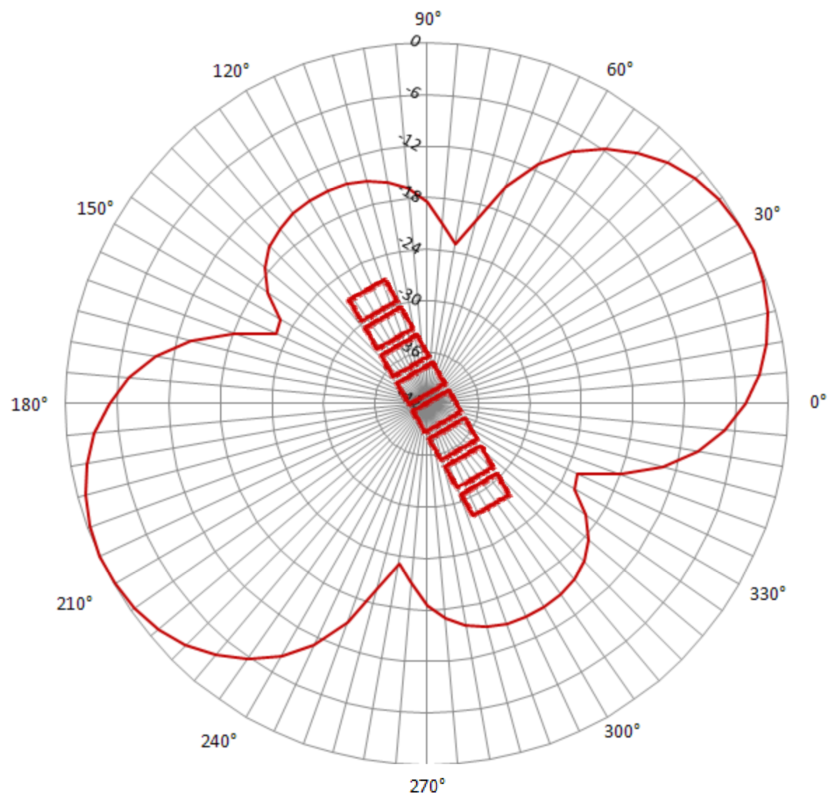



80 Hz polar graph of 16x dual 18” subwoofers

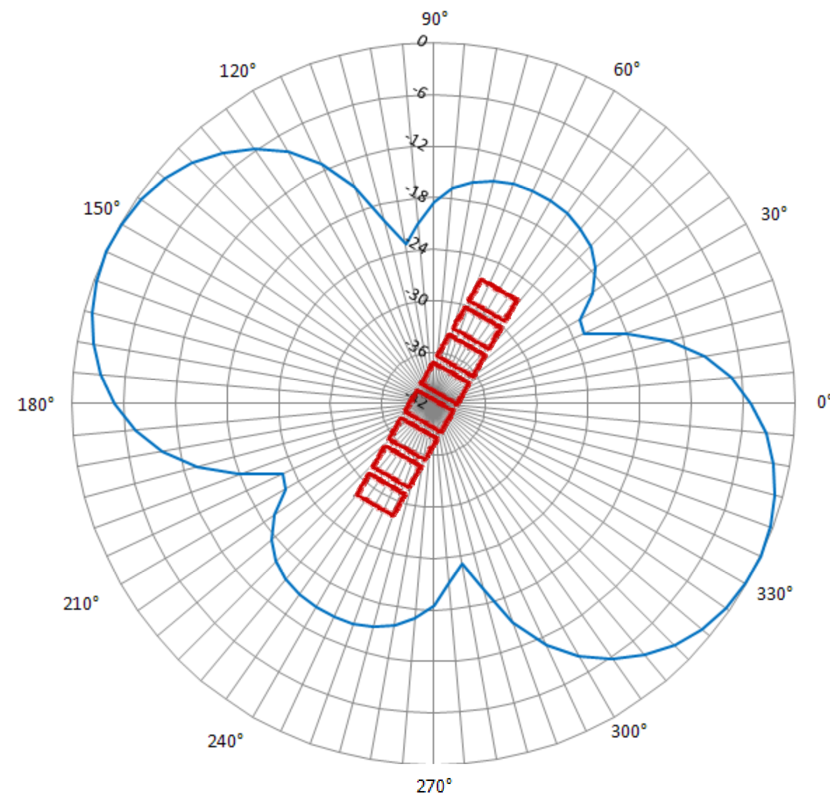
When the array size is one wavelength or greater there is substantial directivity control.

# Steering the Main Lobe

## Mechanical Steering – the array is tilted




30° Up

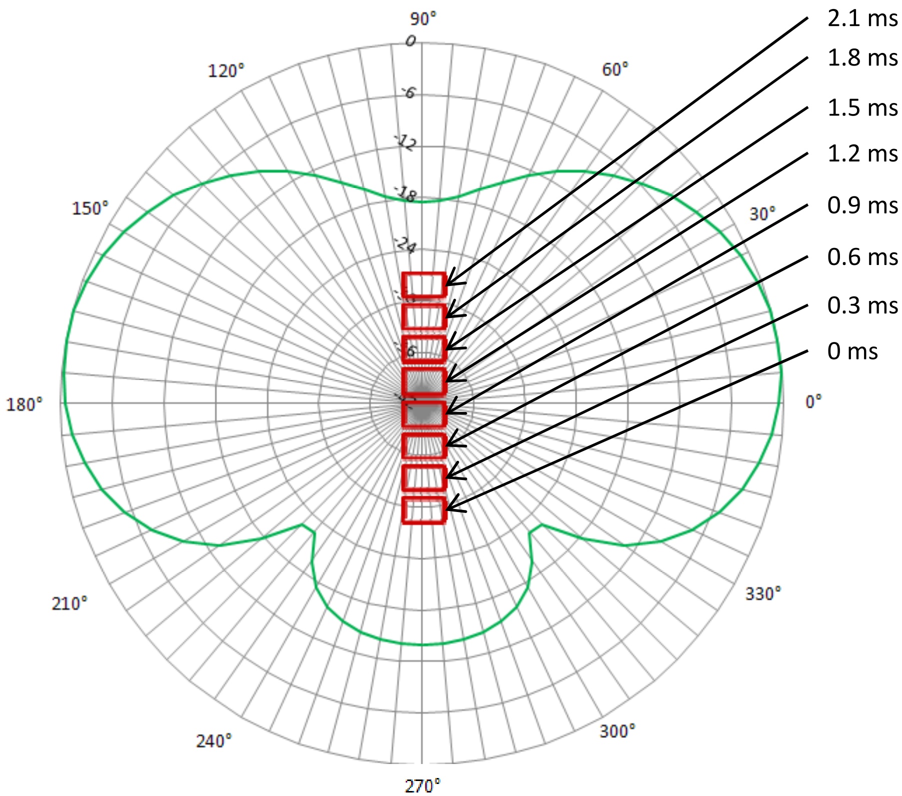



30° Down

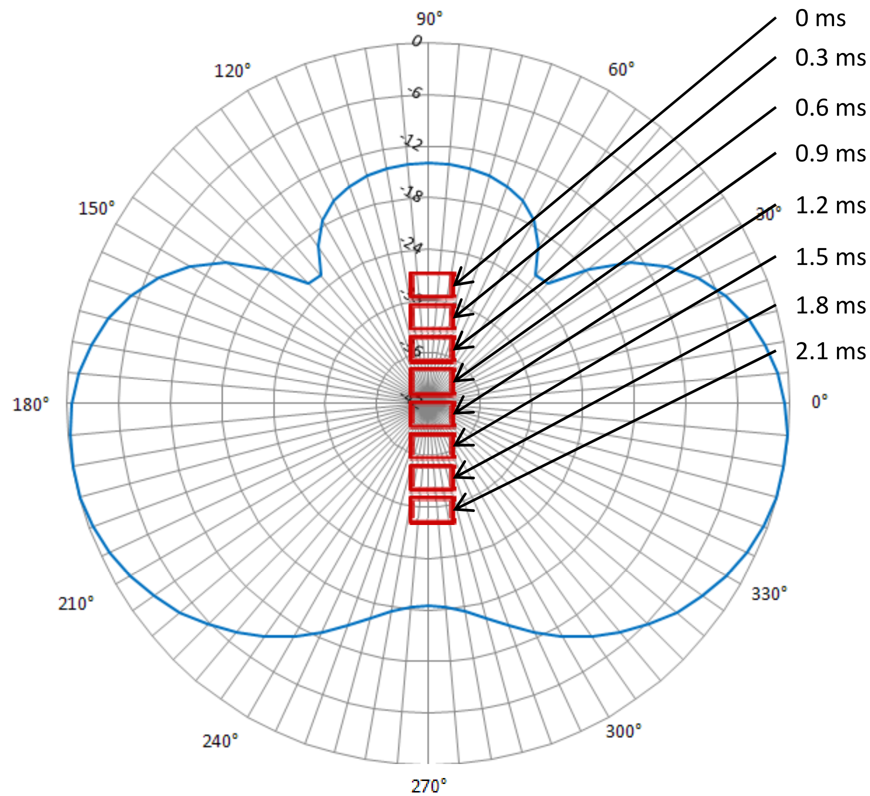
Note that the rear lobe also follows the orientation of the array. It points in the opposite direction of the front lobe.

# Steering the Main Lobe

## Electrical Steering – the same incremental delay is applied to each box




10° Up

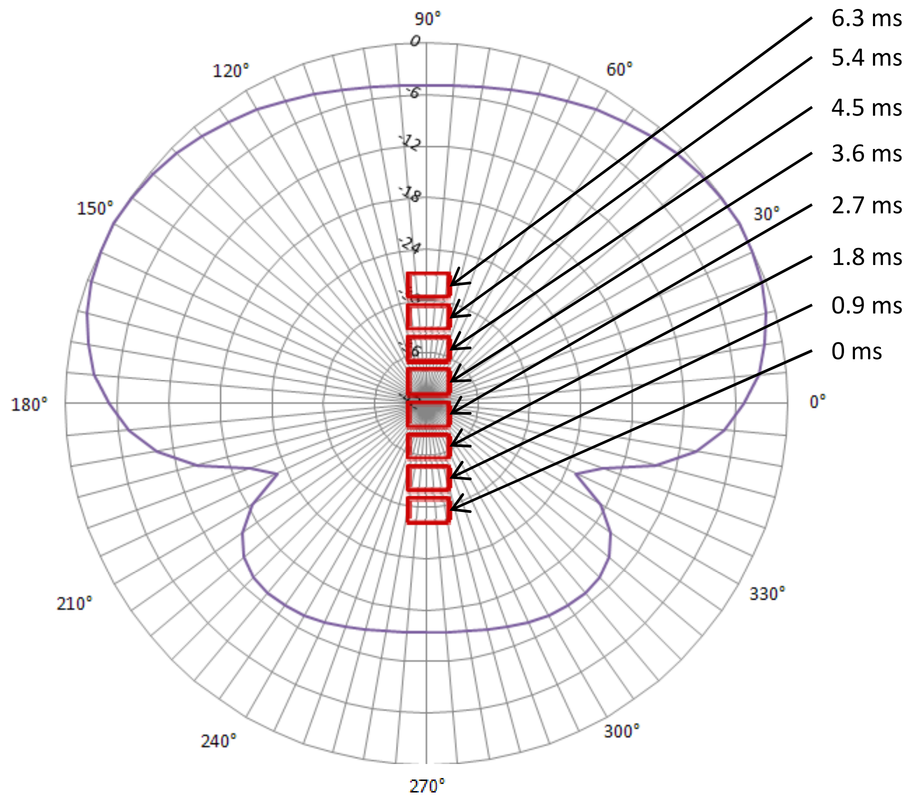



10° Down

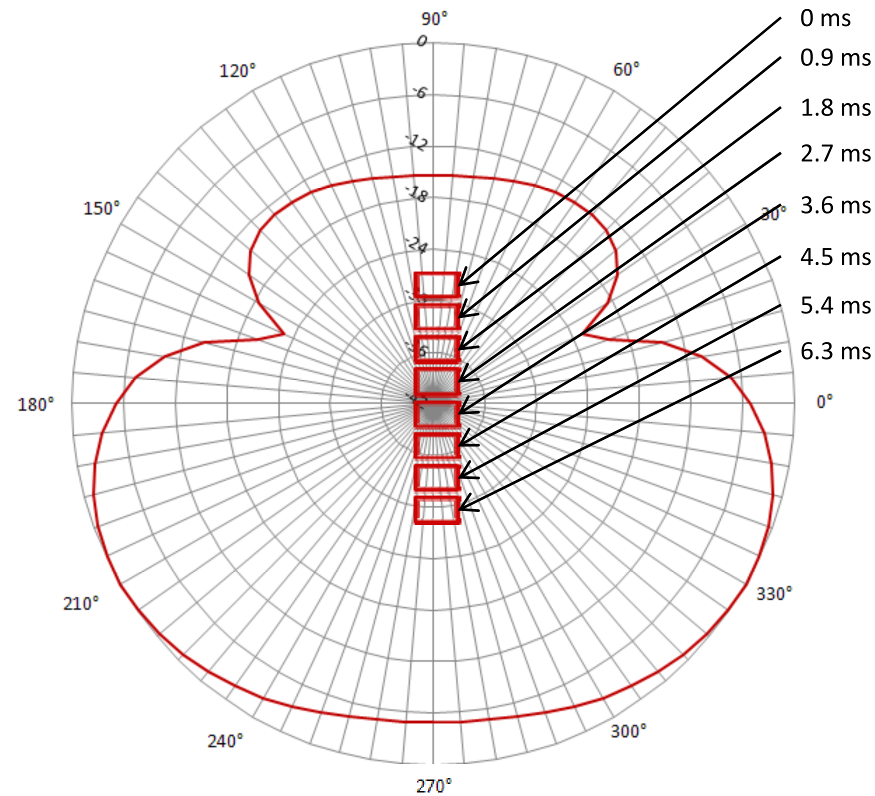
Note that the rear lobe is pointing in the ***same*** direction as the front lobe.

# Steering the Main Lobe

## Electrical Steering – the same incremental delay is applied to each box




30° Up

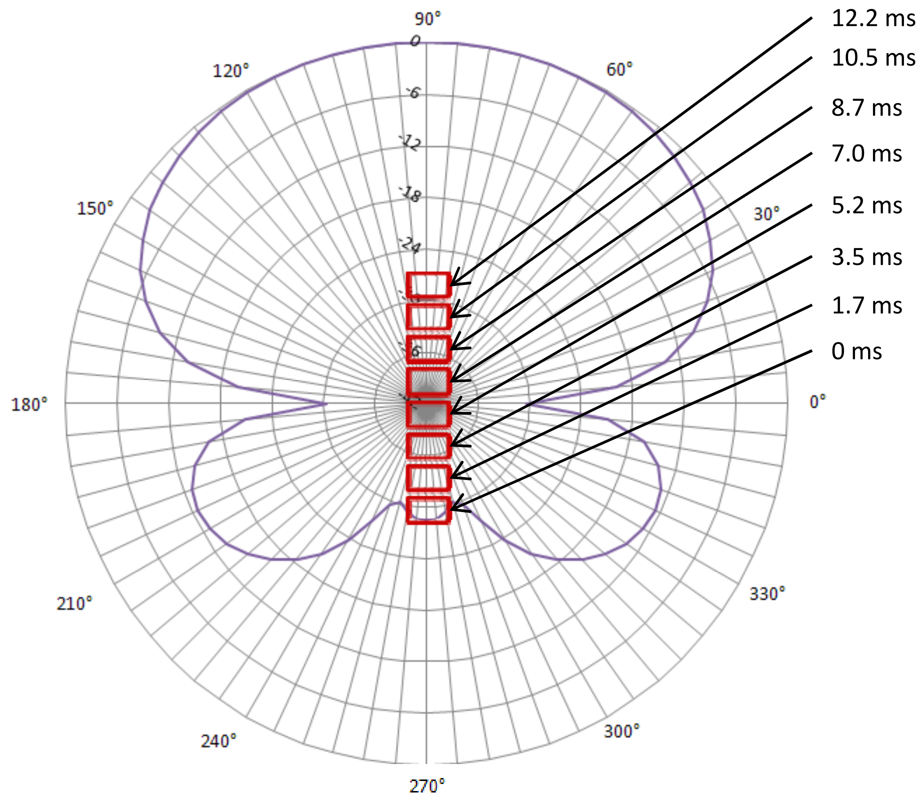



30° Down

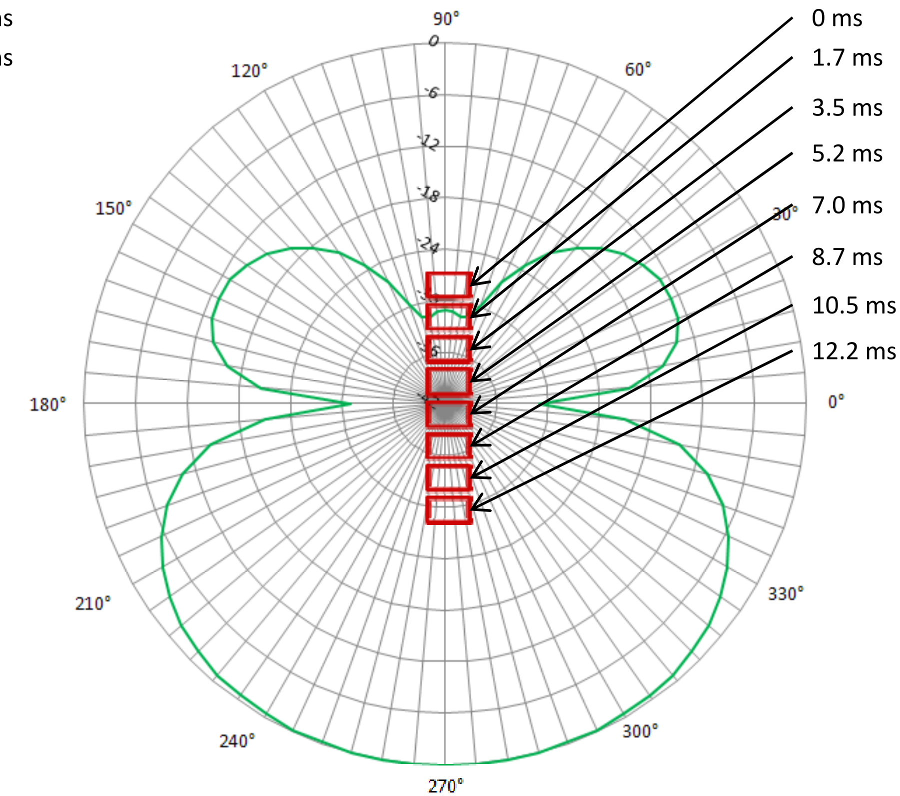
Note that as the steering increases the front and rear lobes begin to merge.

# Steering the Main Lobe

End-Fire Array – when the inter-box delay is equal to the inter-box spacing




90° Up



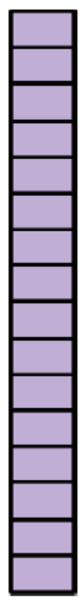

90° Down

Each individual box is delayed back to the rear box so that, on-axis, all of the energy arrives at the same time.

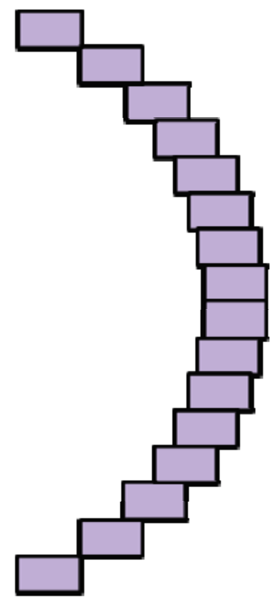
# Wave Front Shaping – Broadening the Main Lobe

Curving the array will decrease the directivity and broaden the coverage pattern.

Often there may not be sufficient space for a curved subwoofer array or time to accurately position each box in the array.



16 Box Straight Array

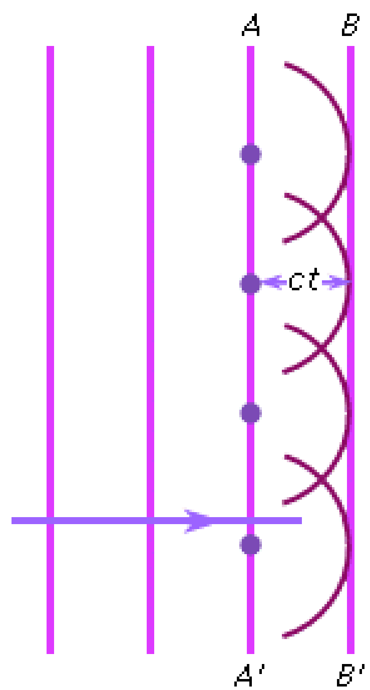


16 Box Circular Curved Array

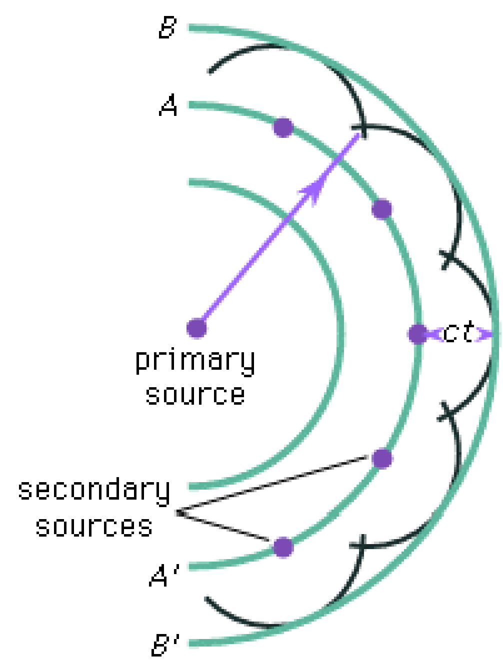
# Wave Front Shaping – Broadening the Main Lobe

**Huygens' Principle**

A wave front can be represented by a collection of point sources on that wave front. These point sources can be thought of as radiating secondary wave fronts. The propagation of the original wave front can be constructed from the superposition of the propagation of the secondary wave fronts.




plane wavefronts

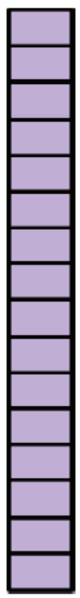



spherical wavefronts

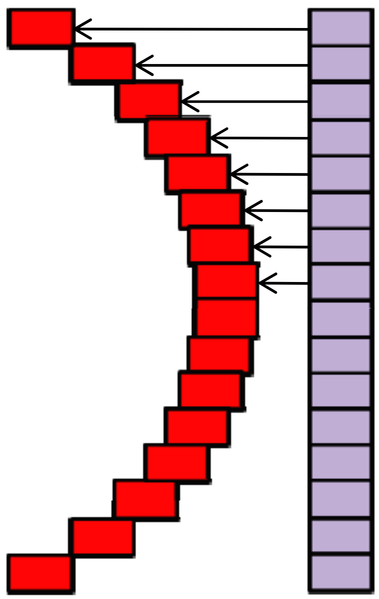
# Wave Front Shaping – Broadening the Main Lobe

The array can be curved electrically, instead of mechanically, by using delay.

The boxes farther from the center must be delayed progressively more. The curve is symmetrical so one delay output can drive two boxes.



16 Box Straight Array

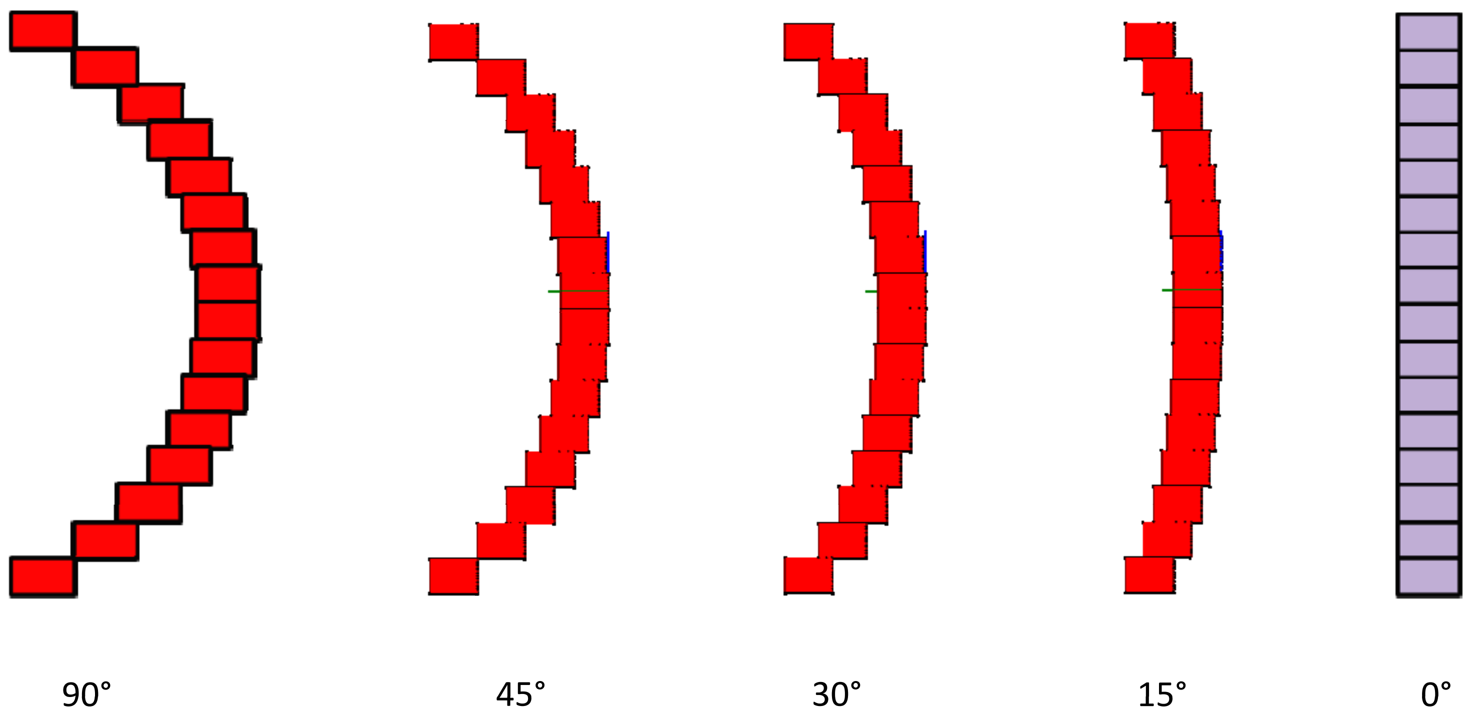


16 Box Circular Curved Array

# Wave Front Shaping – Broadening the Main Lobe

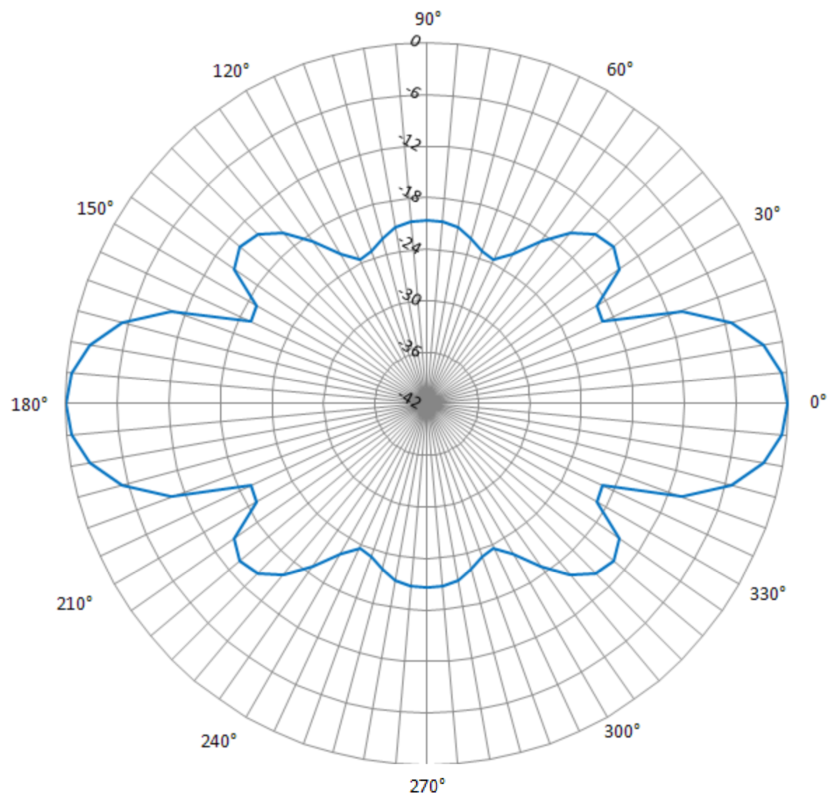
The array is configured mechanically as a straight line.

The amount of delay can be varied to yield any amount of curvature from 0° to 90°.

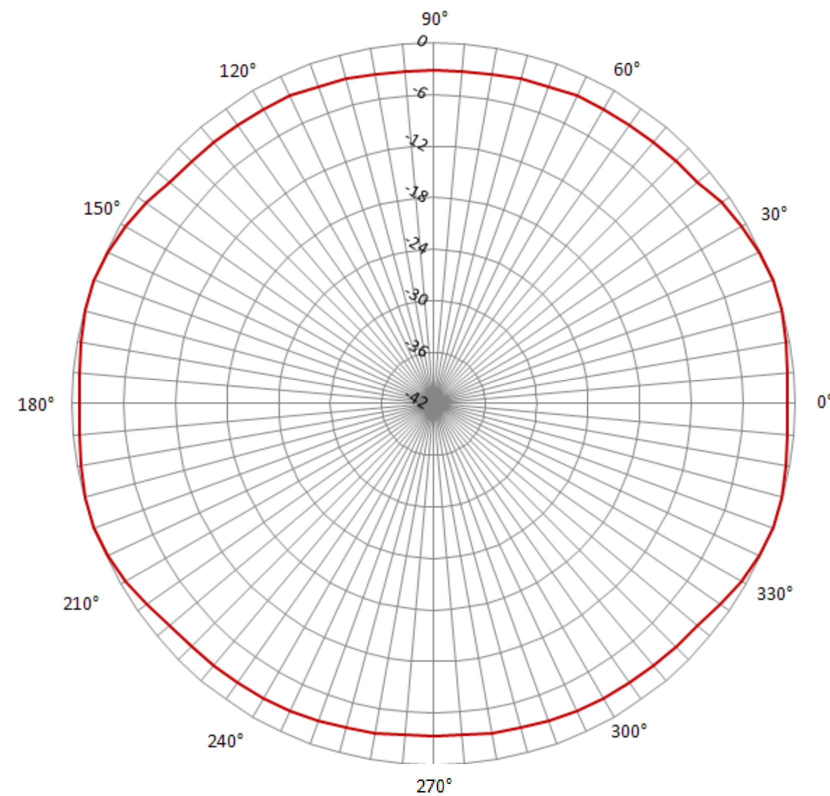


# Wave Front Shaping – Broadening the Main Lobe

Comparison of straight array with various amounts of curvature via delay



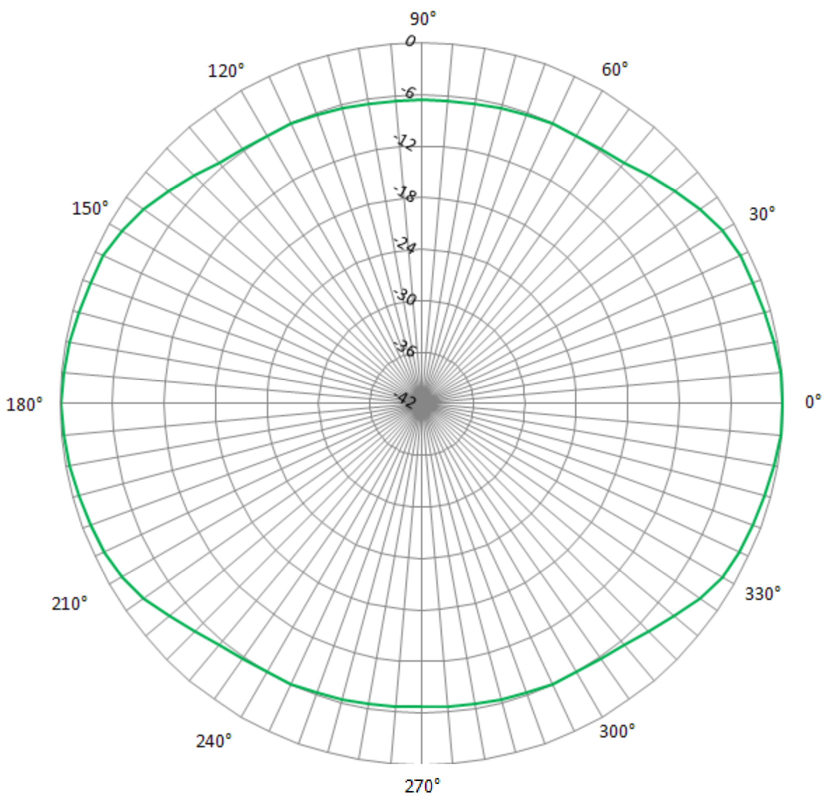

16 Box Straight Array, No Delay Curvature



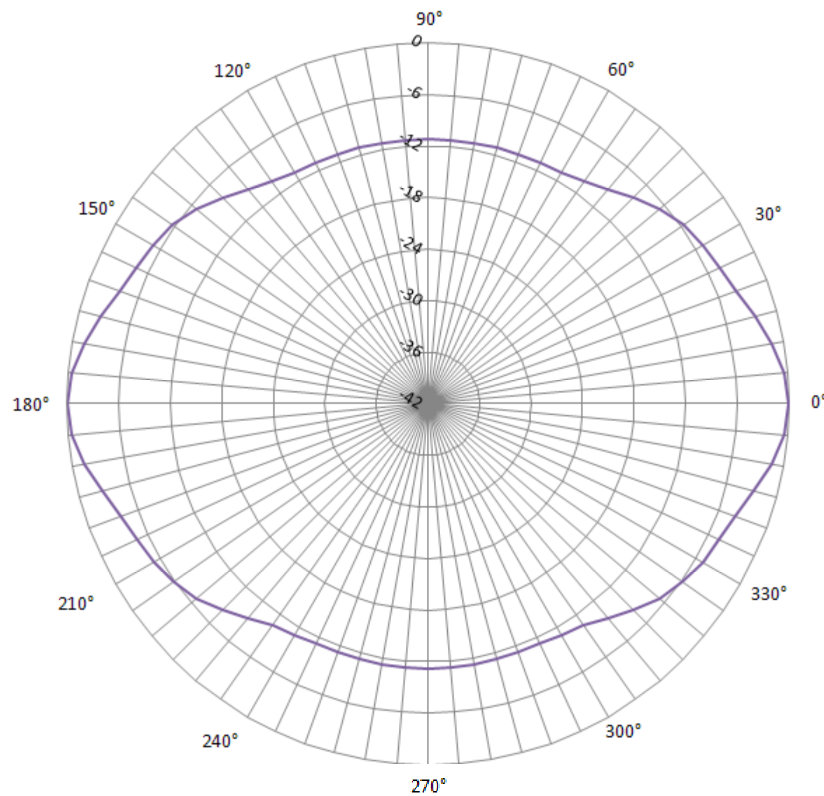

16 Box Straight Array, Curved 90° with Delay

# Wave Front Shaping – Broadening the Main Lobe

Comparison of straight array with various amounts of curvature via delay



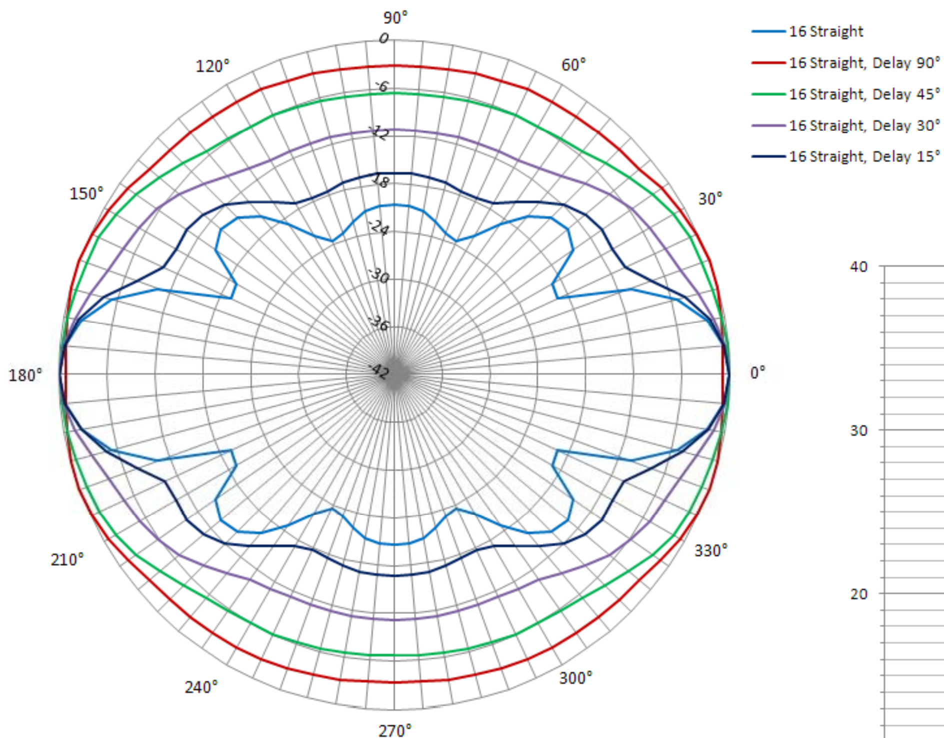

16 Box Straight Array, Curved 45° with Delay



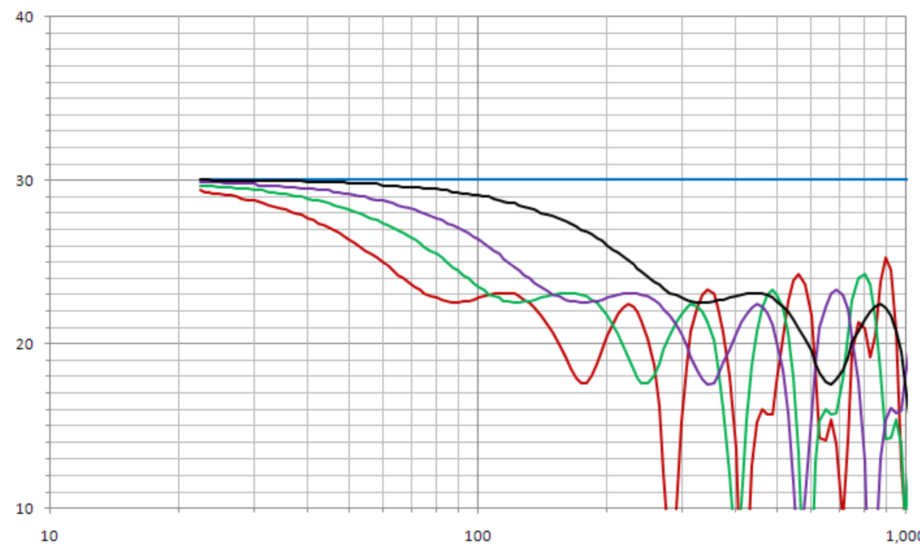

16 Box Straight Array, Curved 30° with Delay

# Wave Front Shaping – Broadening the Main Lobe

Comparison of straight array with various amounts of curvature via delay




Polar Response at 80 Hz



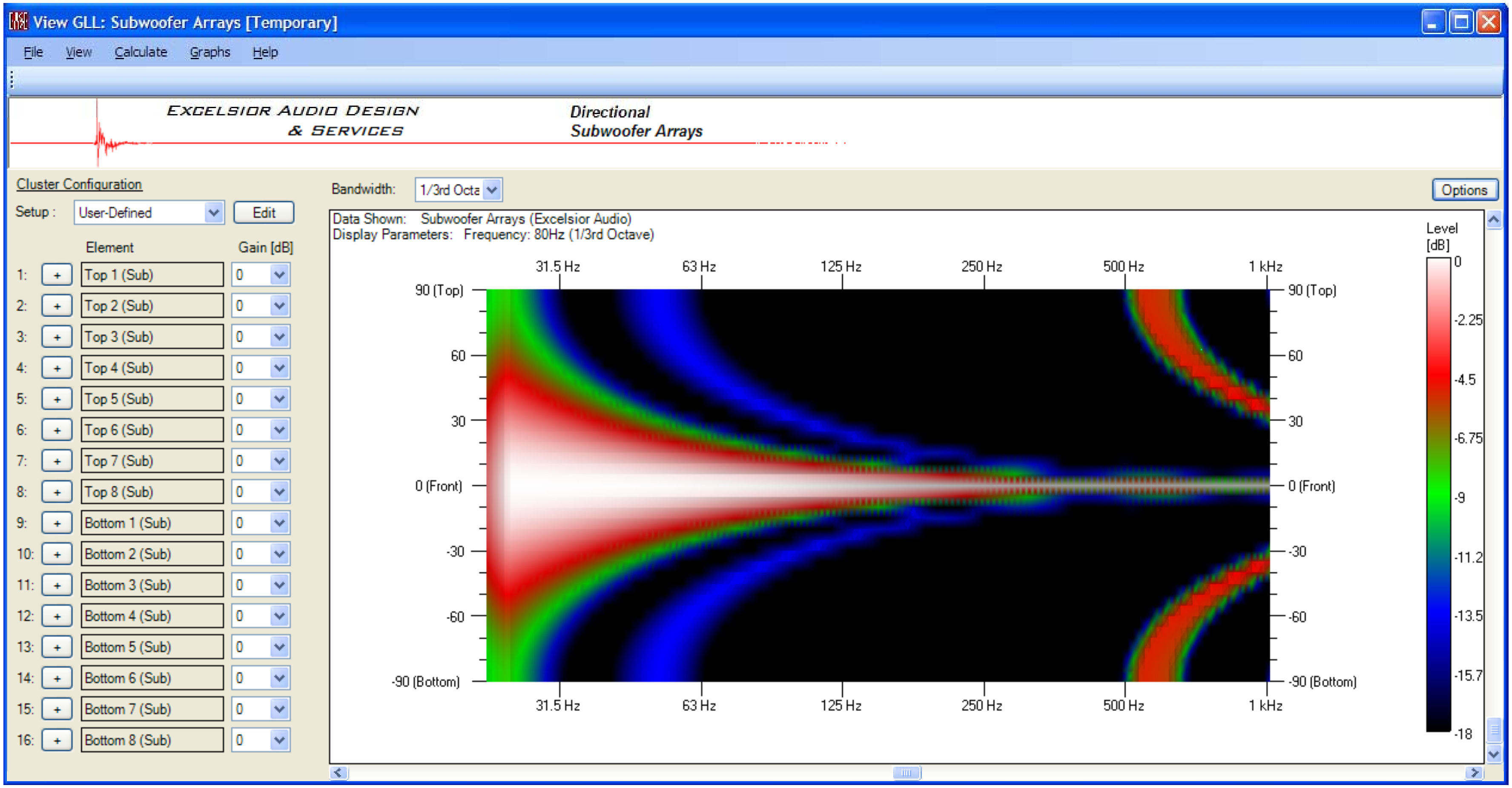

On-Axis Magnitude Response

16 Box Straight Array, Curved with Delay

# Wave Front Shaping – Broadening the Main Lobe

## Directivity map – SPL as a function of both frequency and off-axis angle

Note the beamwidth narrowing as frequency increases.

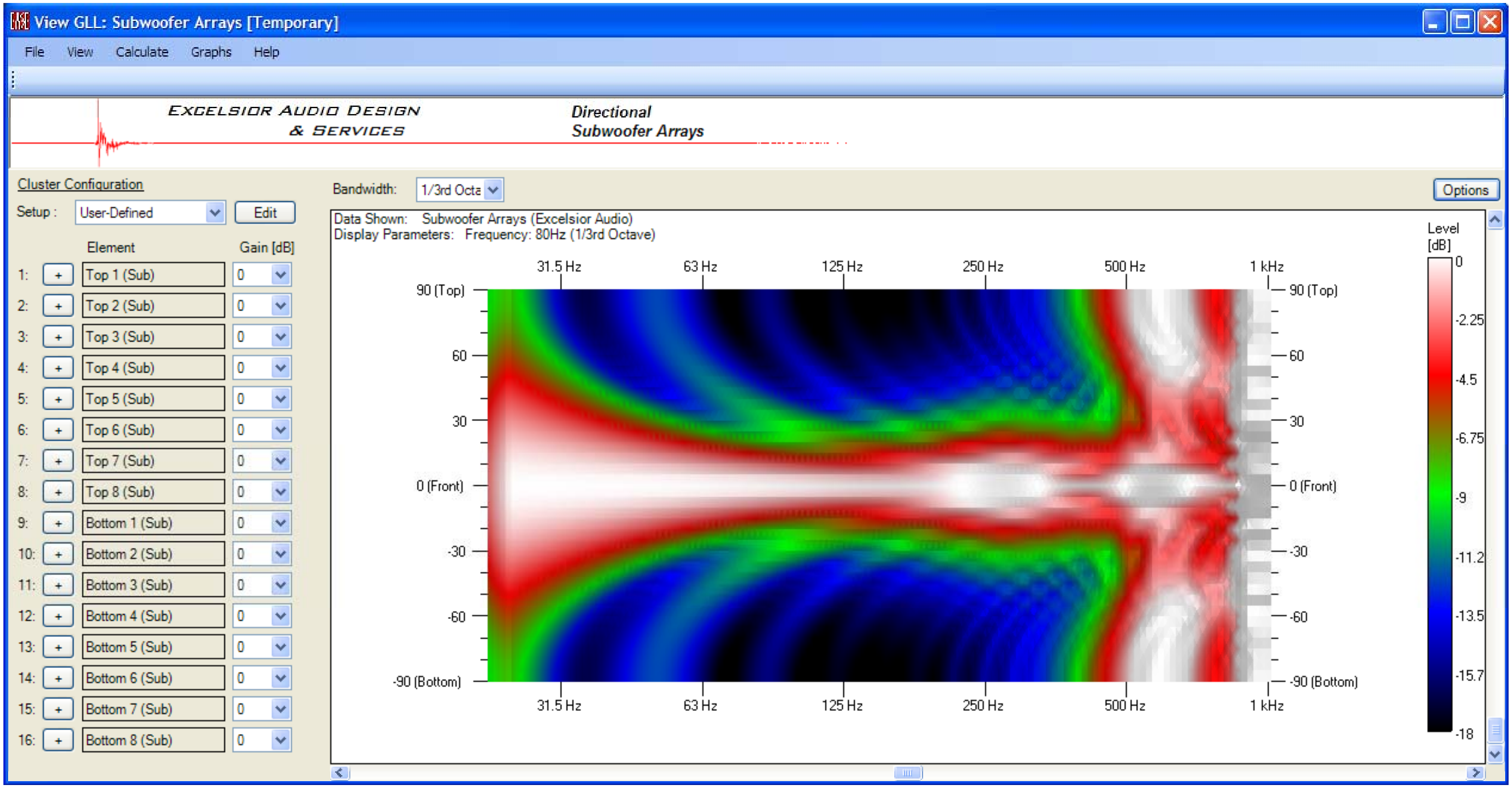



16 Box Straight Array, No Delay Curvature

# Wave Front Shaping – Broadening the Main Lobe

## Directivity map – SPL as a function of both frequency and off-axis angle

Note the slight increase in beamwidth compared to the straight array.

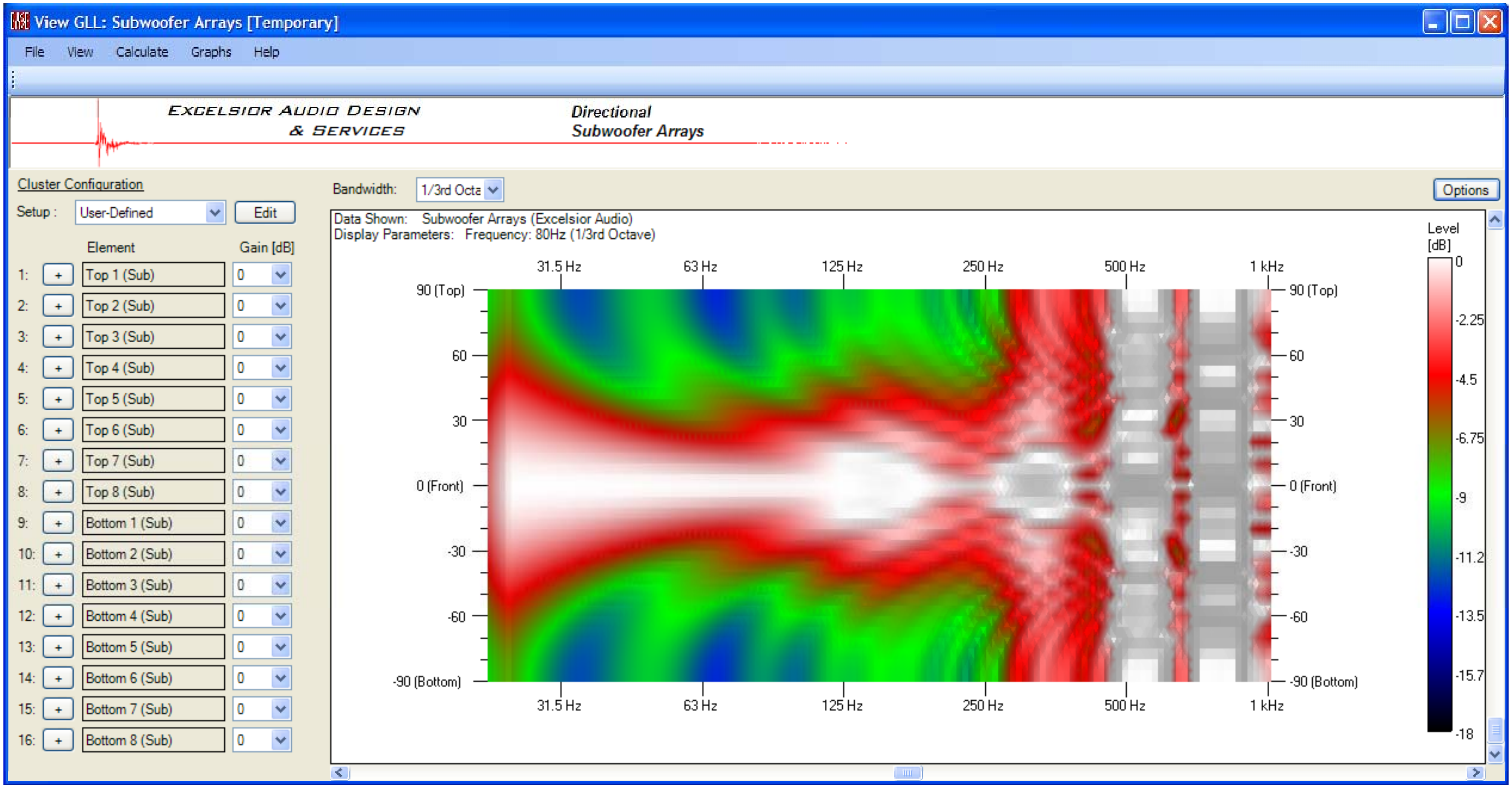



16 Box Straight Array, Curved 15° with Delay

# Wave Front Shaping – Broadening the Main Lobe

## Directivity map – SPL as a function of both frequency and off-axis angle

The beamwidth continues to increase as the virtual curve of the array increases.

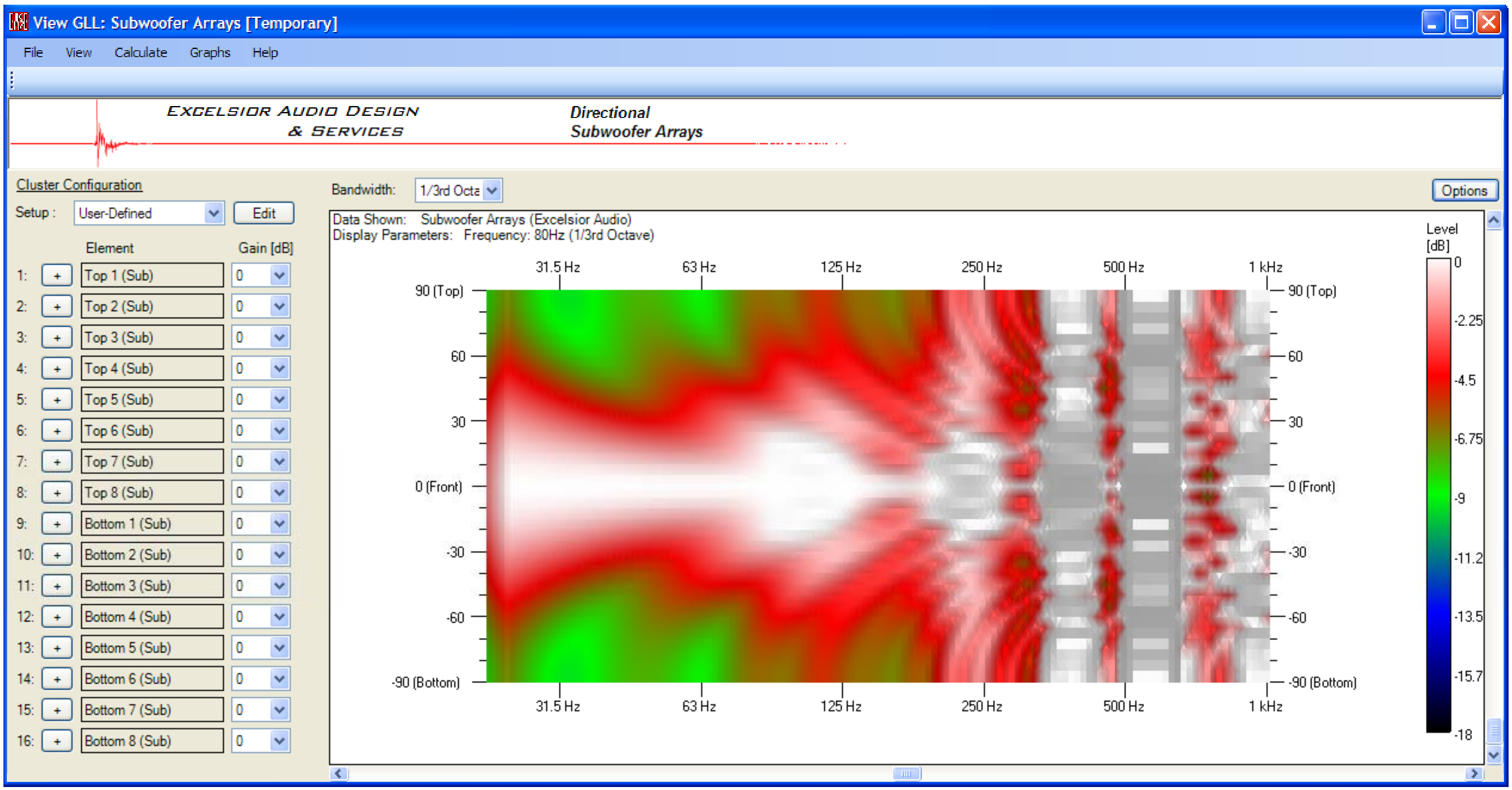



16 Box Straight Array, Curved 30° with Delay

# Wave Front Shaping – Broadening the Main Lobe

## Directivity map – SPL as a function of both frequency and off-axis angle

The beamwidth is almost a constant 90° from 20 – 80 Hz.

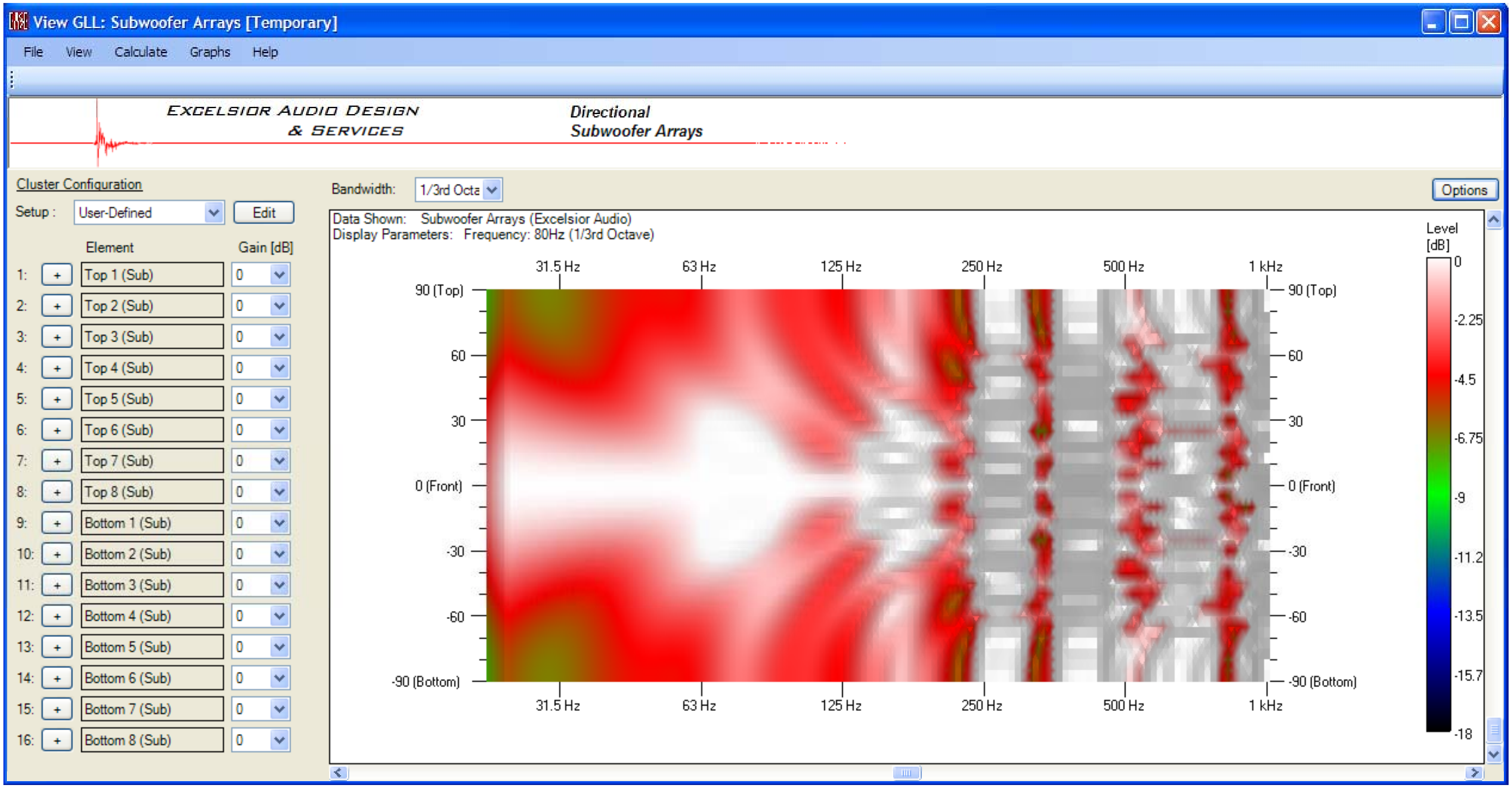



16 Box Straight Array, Curved 45° with Delay

# Wave Front Shaping – Broadening the Main Lobe

## Directivity map – SPL as a function of both frequency and off-axis angle

The beamwidth is almost a constant 180° from 20 – 80 Hz, with only slight narrowing around 30 Hz.




16 Box Straight Array, Curved 90° with Delay

# Recap

Directivity control is directly related to the wavelength (frequency) being radiated and also the size of the source, or array, radiating it.

Steering of the main lobe can be done mechanically or electrically.

Wave front shaping can be used to broaden the directivity, or coverage pattern, and can yield fairly constant directivity.

Wave front shaping can be done mechanically or electrically.