Microphone Techniques for Stereo and Multichannel

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What we'll look at

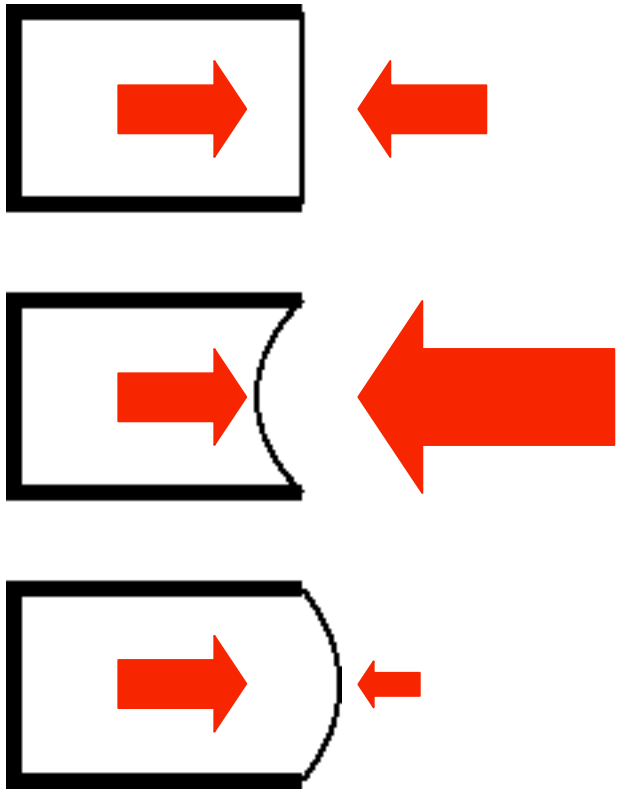
- How microphones behave
- Monitoring environment
- What different microphone configurations do for you

- If something doesn't make sense, stop me and ask at any time!

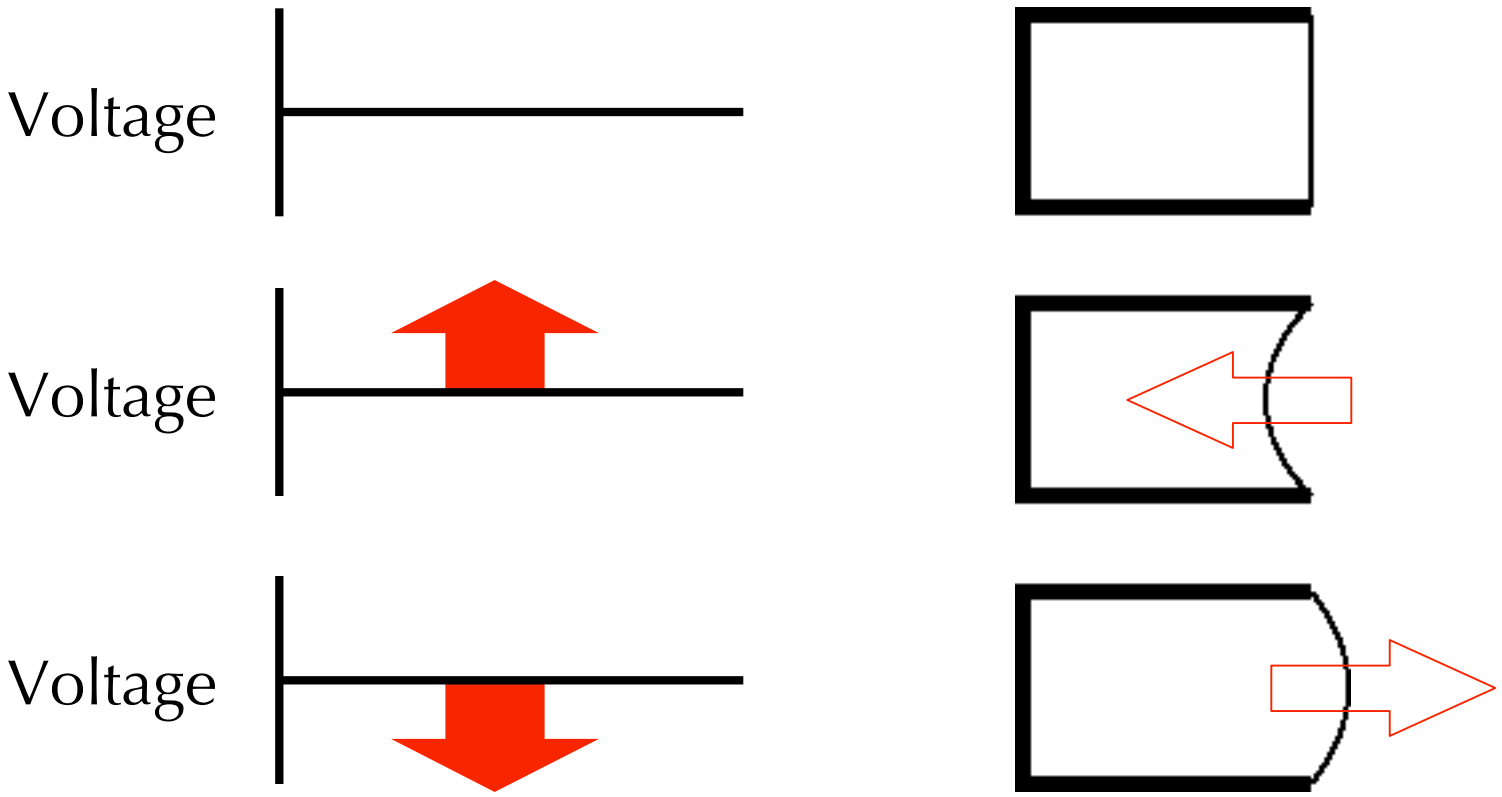
What is sound?

- Today's barometric pressure is about 100 kPa
- Sound is a change in that pressure over time
- A microphone converts that pressure change into a voltage change

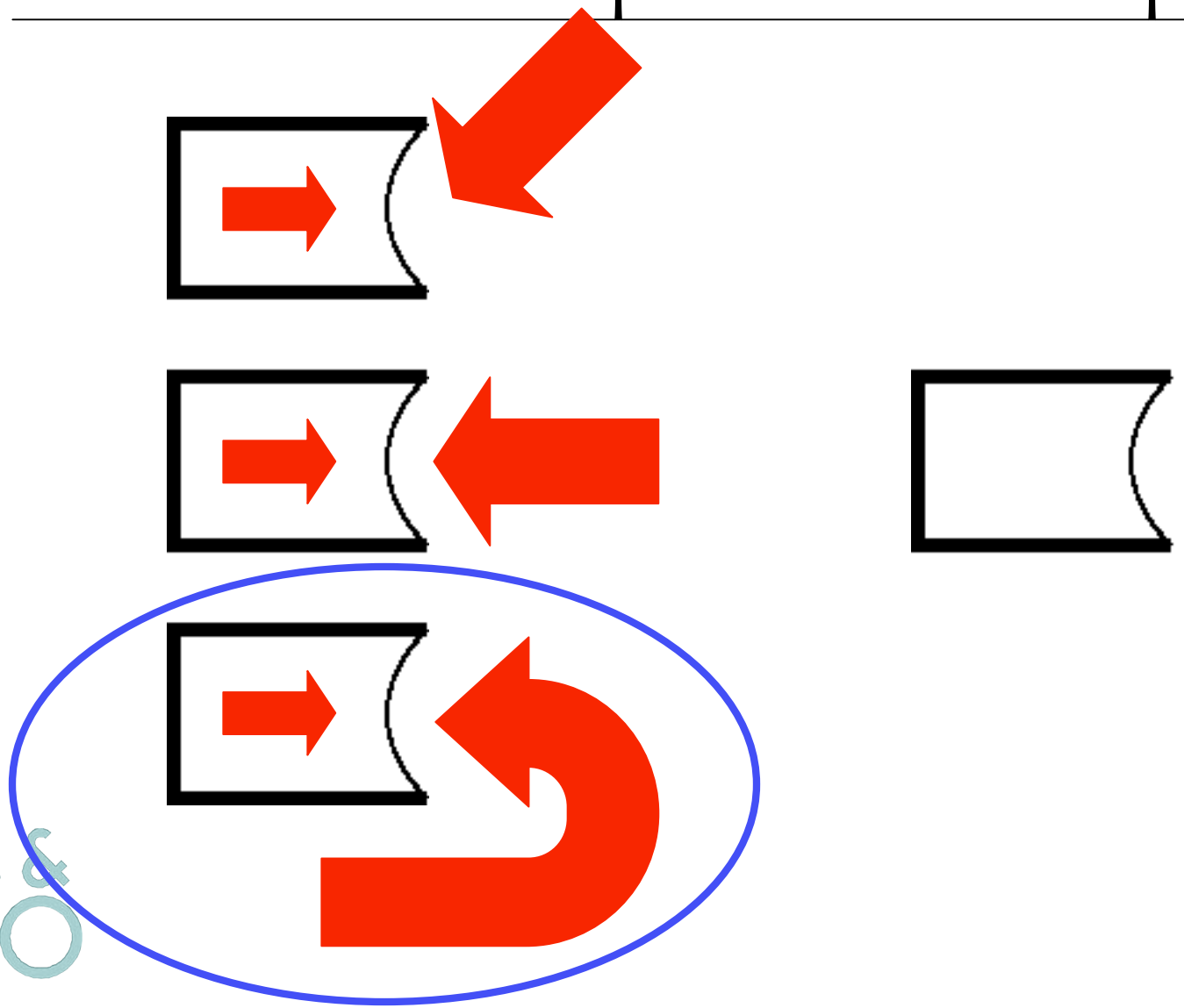
How to make a barometer



How to make a ~~barometer~~ pressure microphone

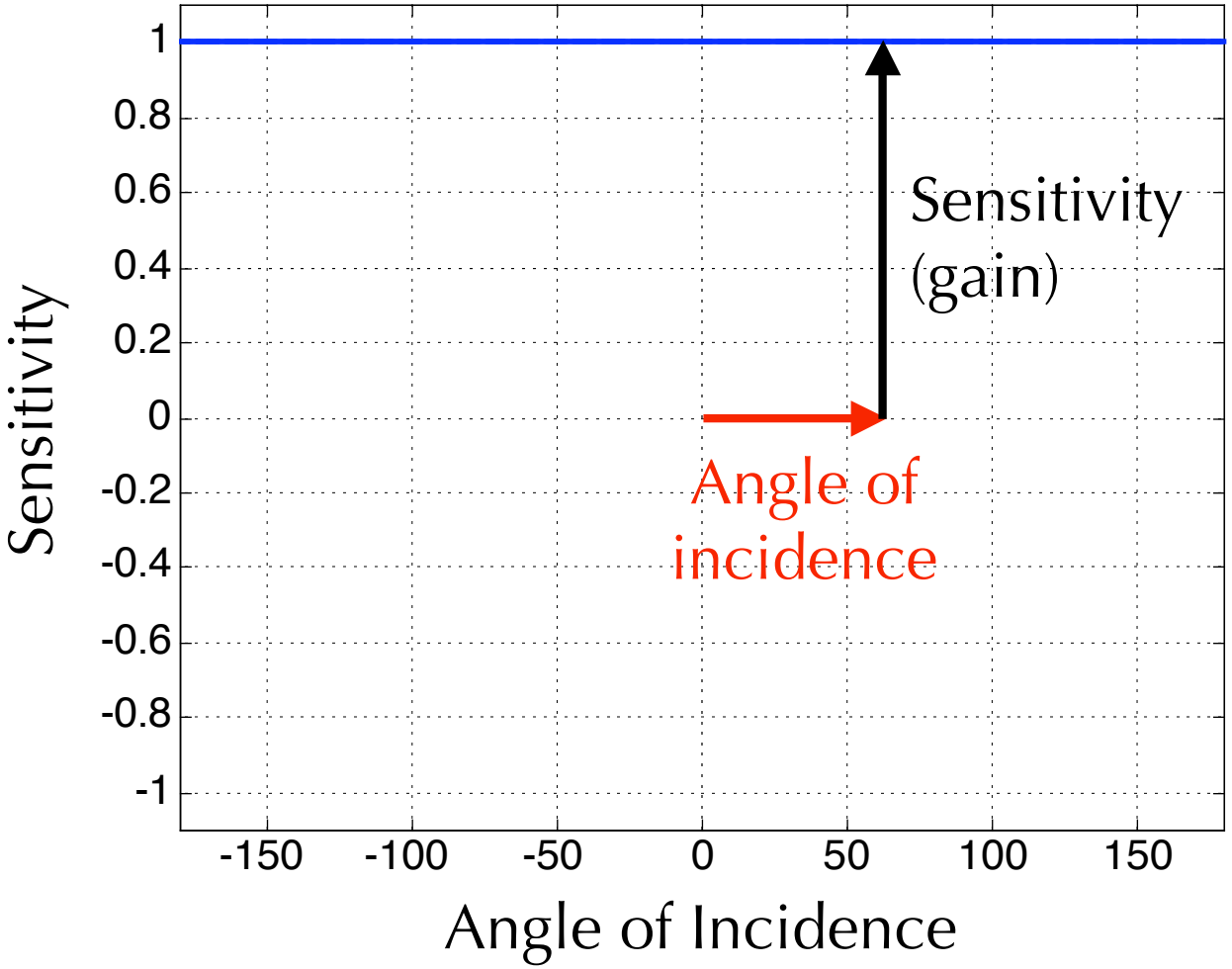


How to make a pressure microphone



Pressure Microphone - Sensitivity

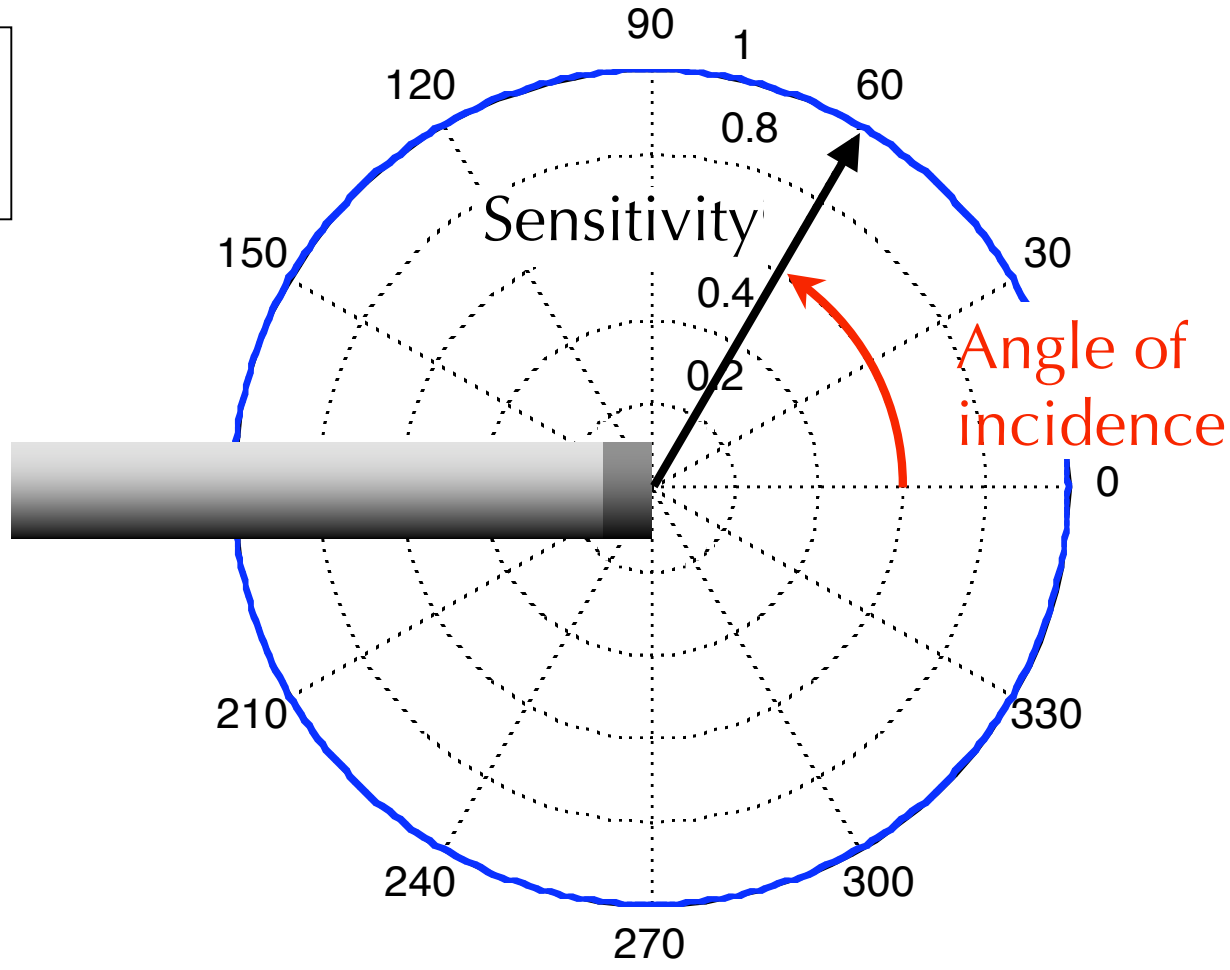
S = 1



Omnidirectional

~~Pressure~~ microphone - Sensitivity

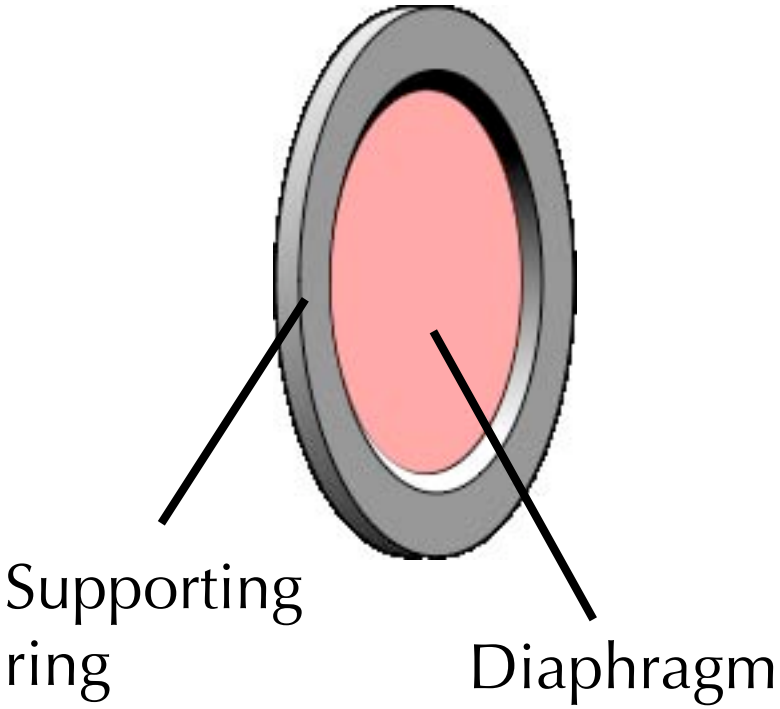
S = 1

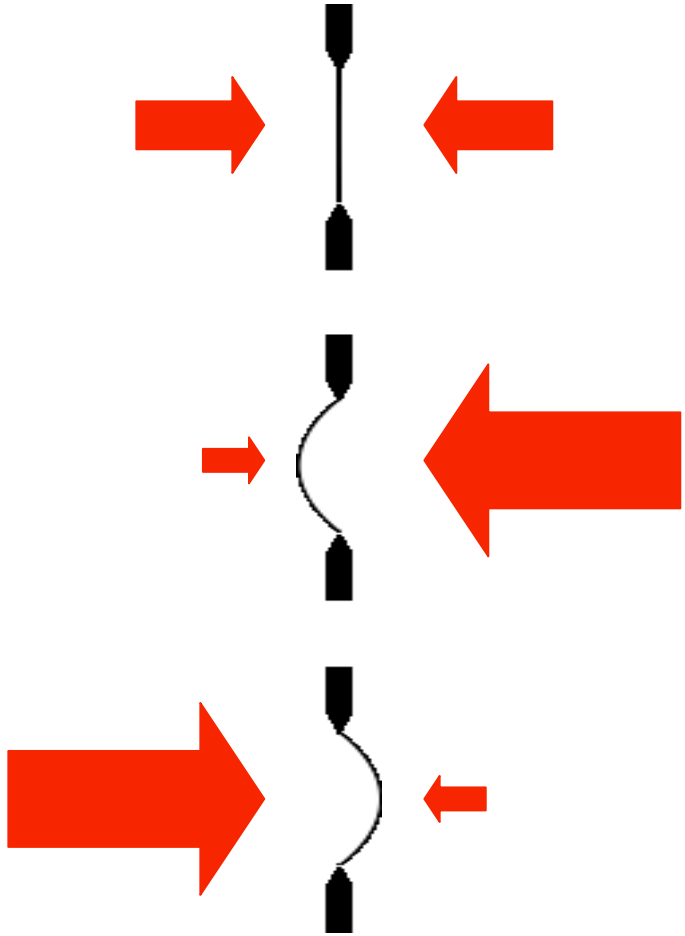


Let's start again…

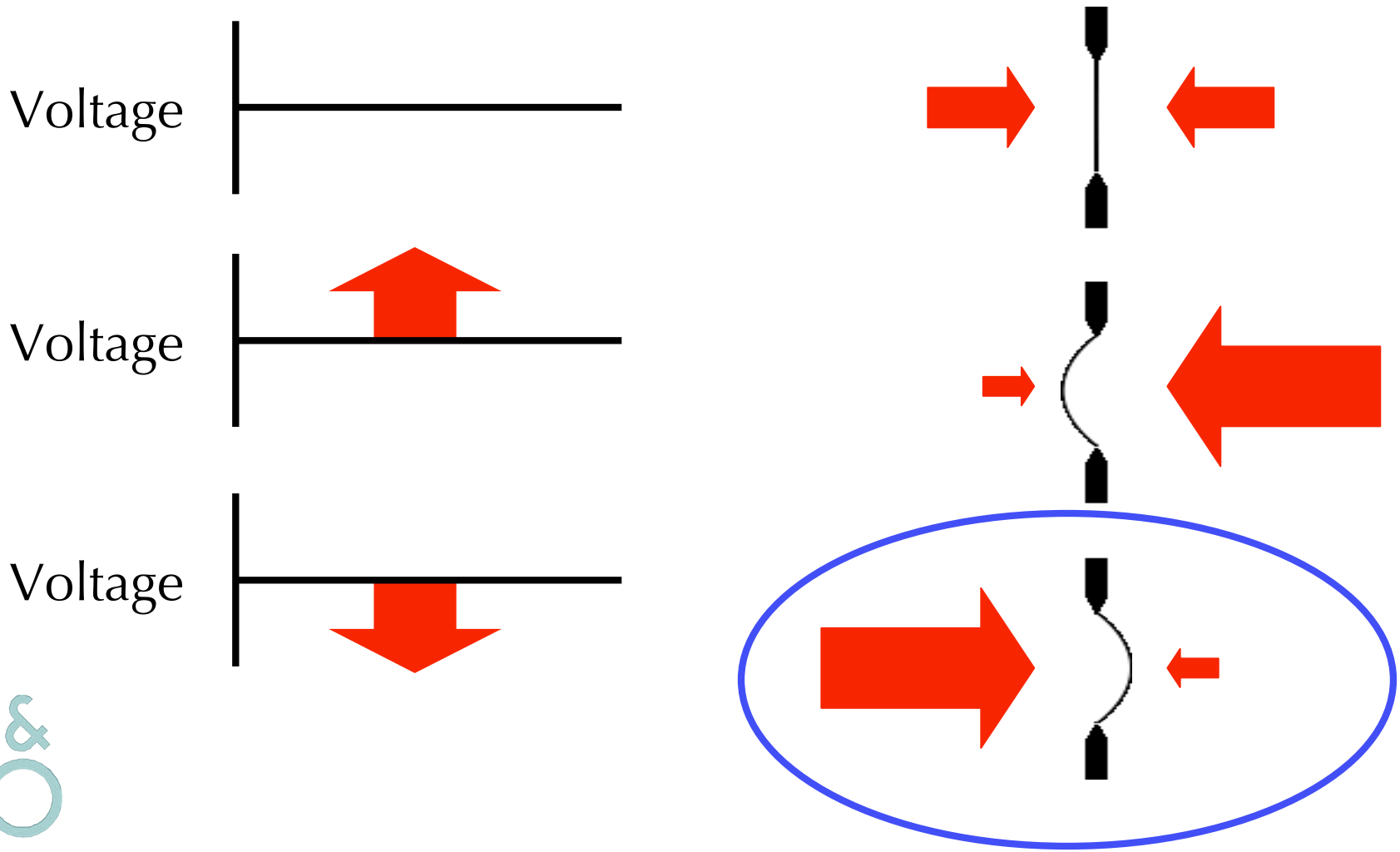
- We'll build another "barometer" but this time without the sealed can
- This means we are measuring the *difference* in pressure on the front and back of the diaphragm
- Pressure Difference = Pressure Gradient

Pressure Gradient microphone - Construction



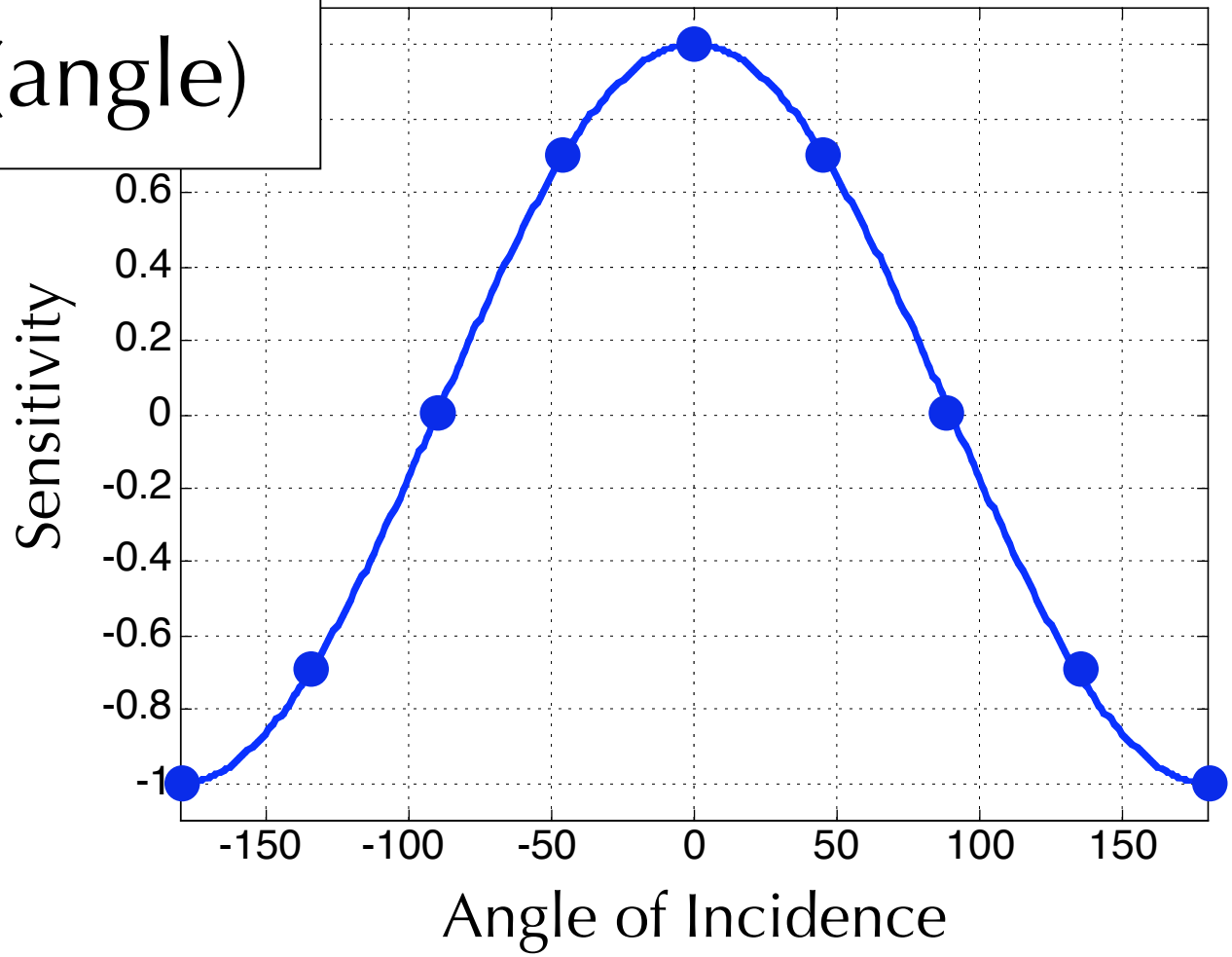


Pressure Gradient microphone - Output



Pressure Gradient microphone - Sensitivity

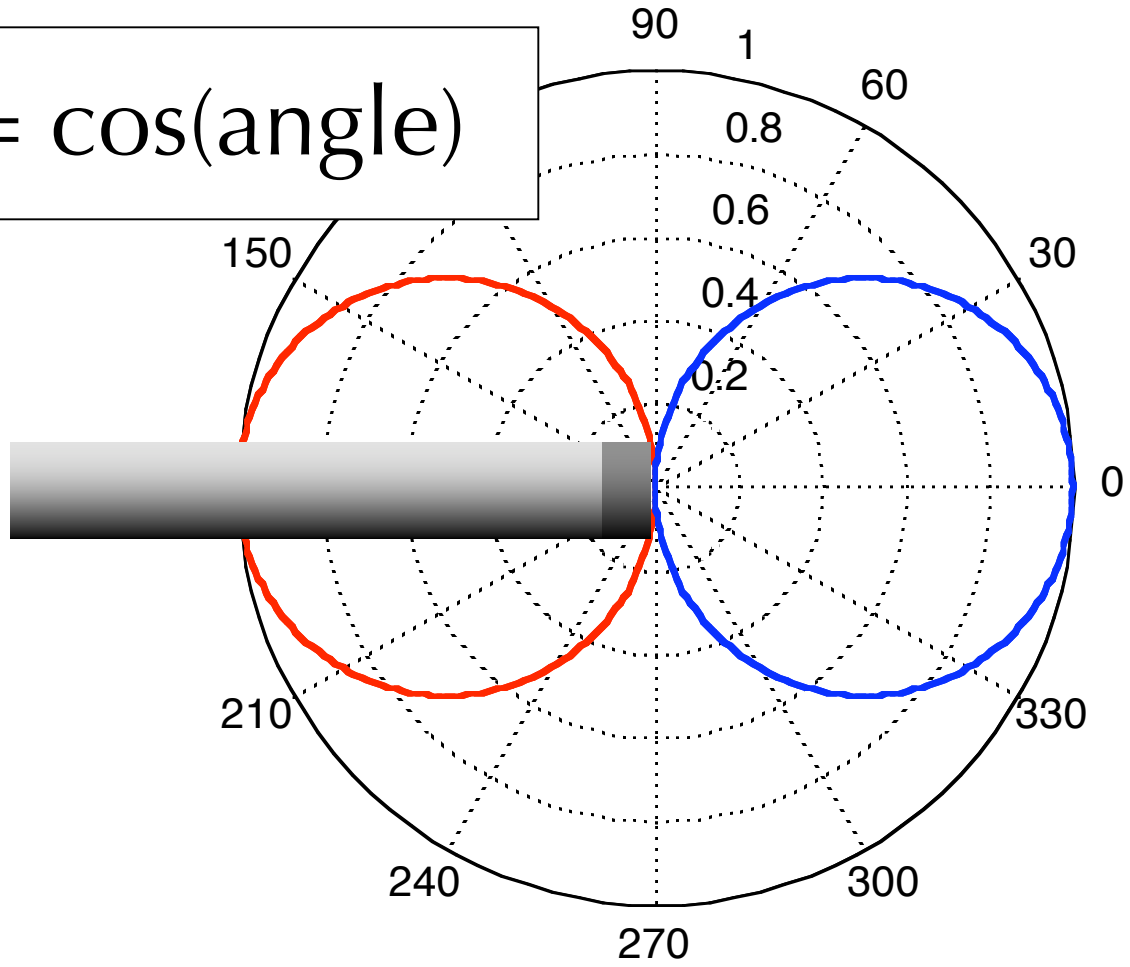
$$S = \cos(\text{angle})$$



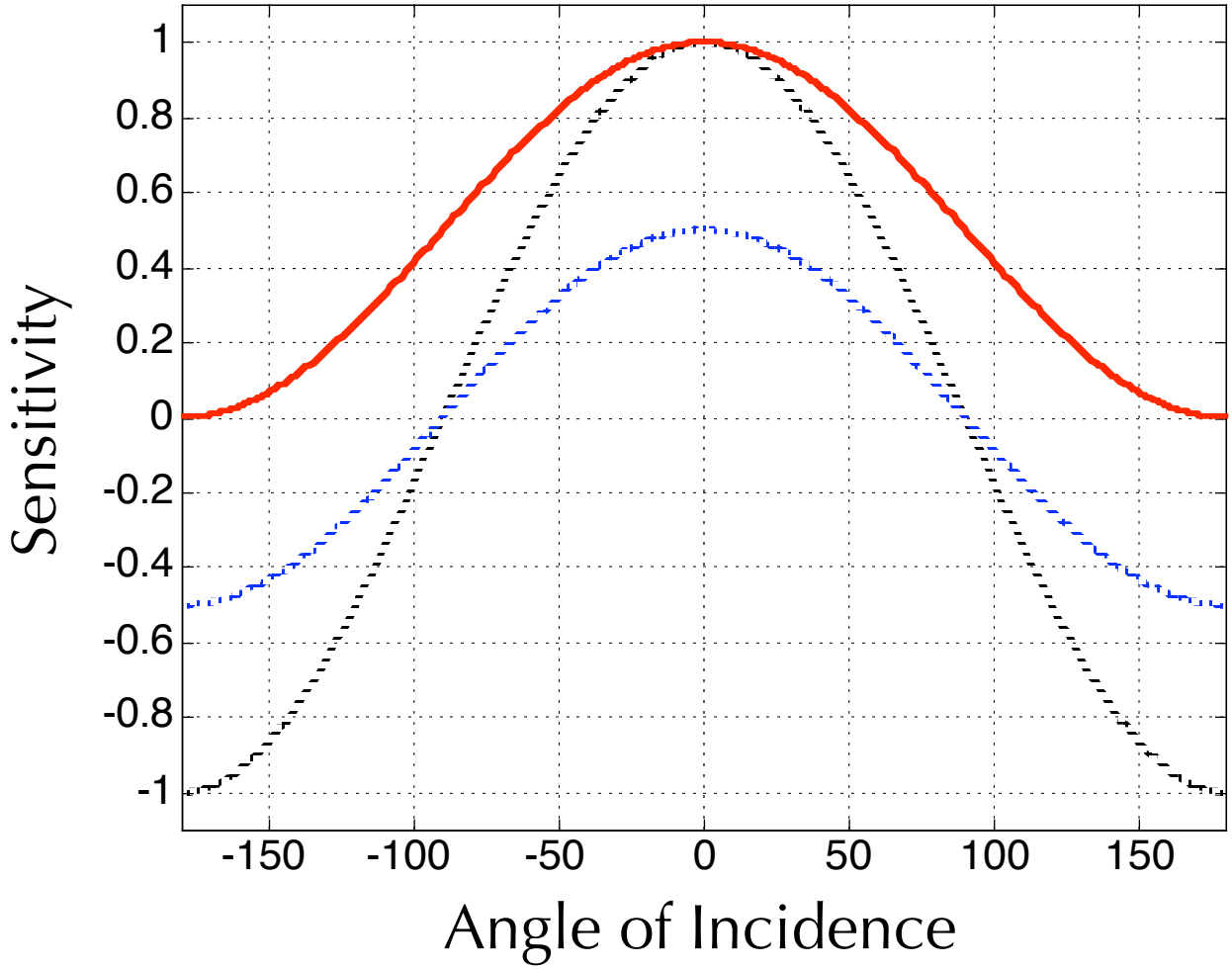
Bidirectional

~~Pressure Gradient~~ microphone - Sensitivity

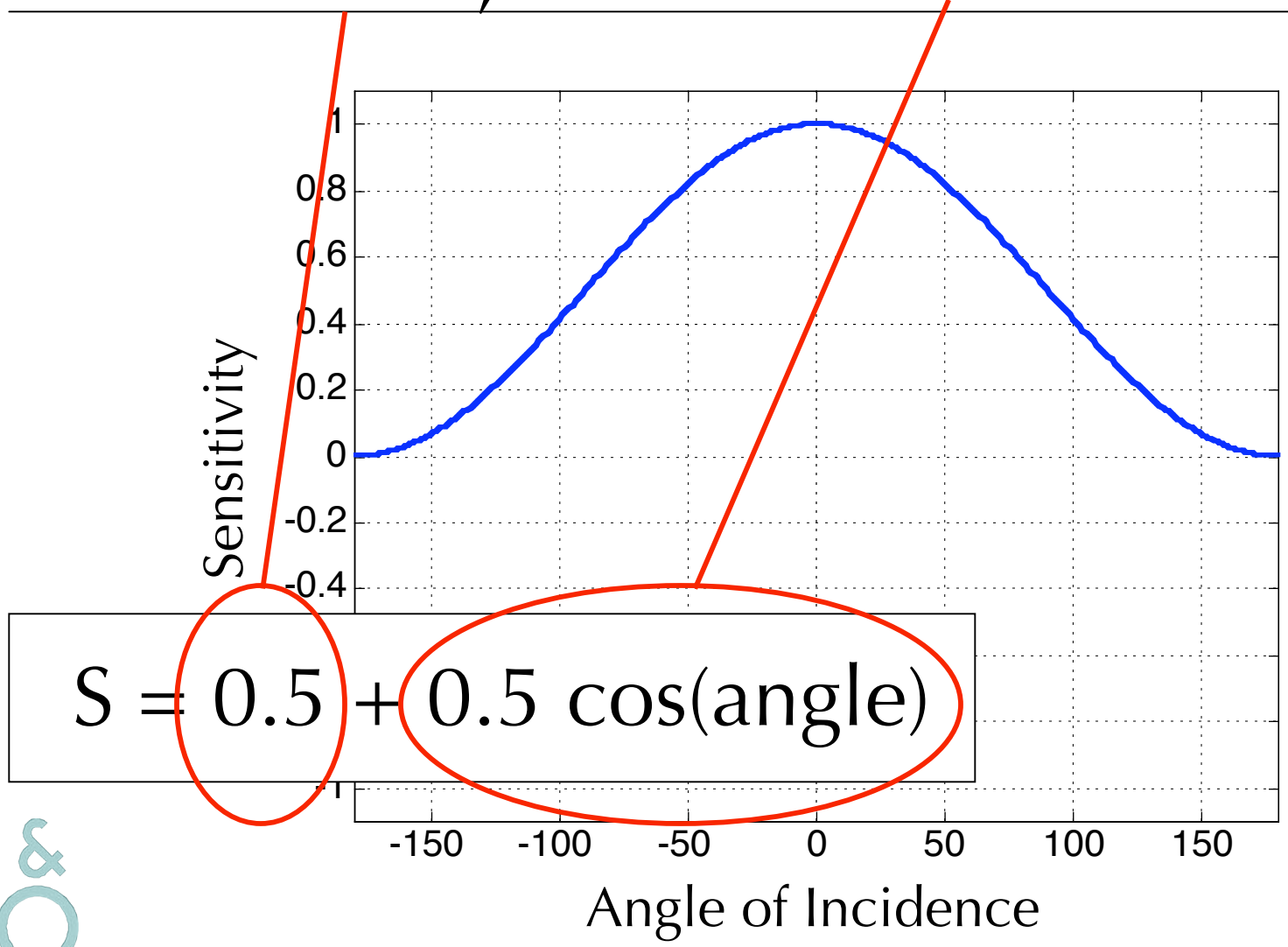
$$S = \cos(\text{angle})$$



Let's add them…

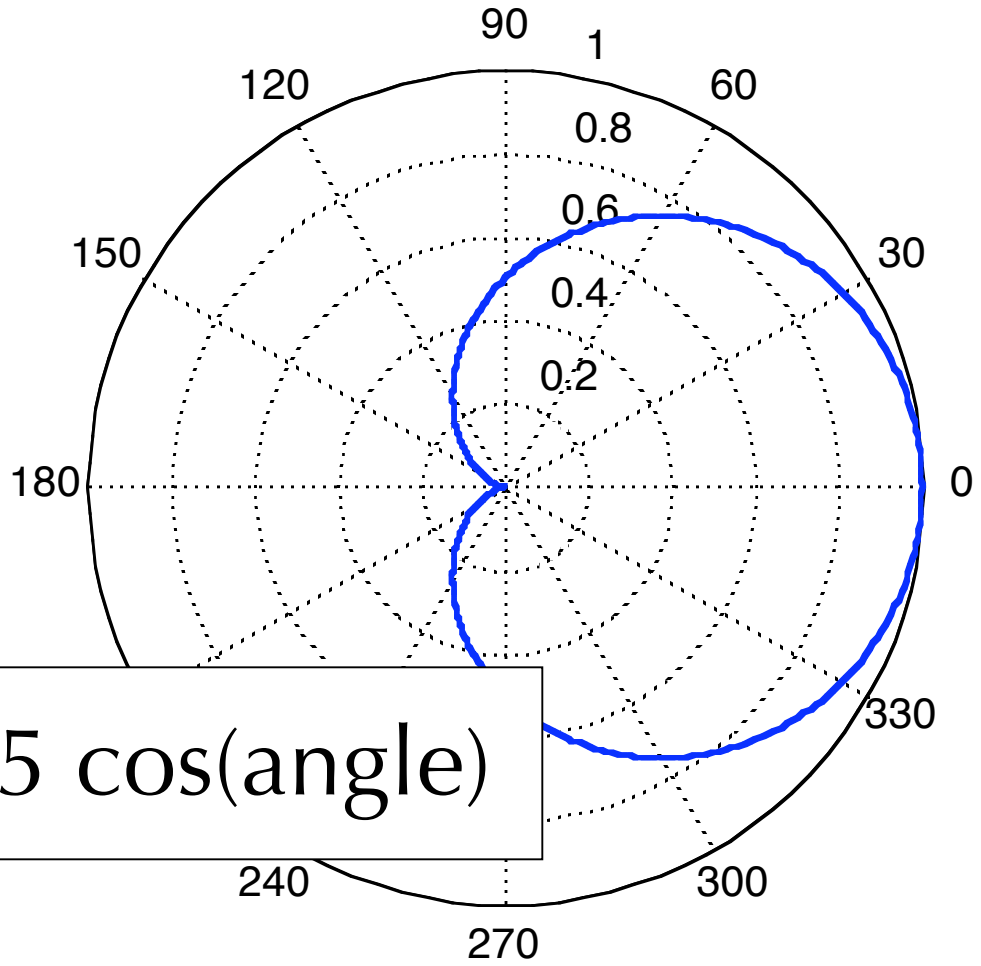


Half-omni, half-bidirectional



Cardioid microphone

~~Half-omni, half-bidirectional~~



$$S = 0.5 + 0.5 \cos(\text{angle})$$

Make your own Polar Patterns

	Pressure (Omnidirectional)	Pressure Gradient (Bidirectional)
Omnidirectional	100%	0%
Subcardioid	75%	25%
Cardioid	50%	50%
Hypercardioid	25%	75%
Bidirectional	0%	100%

Polar Patterns

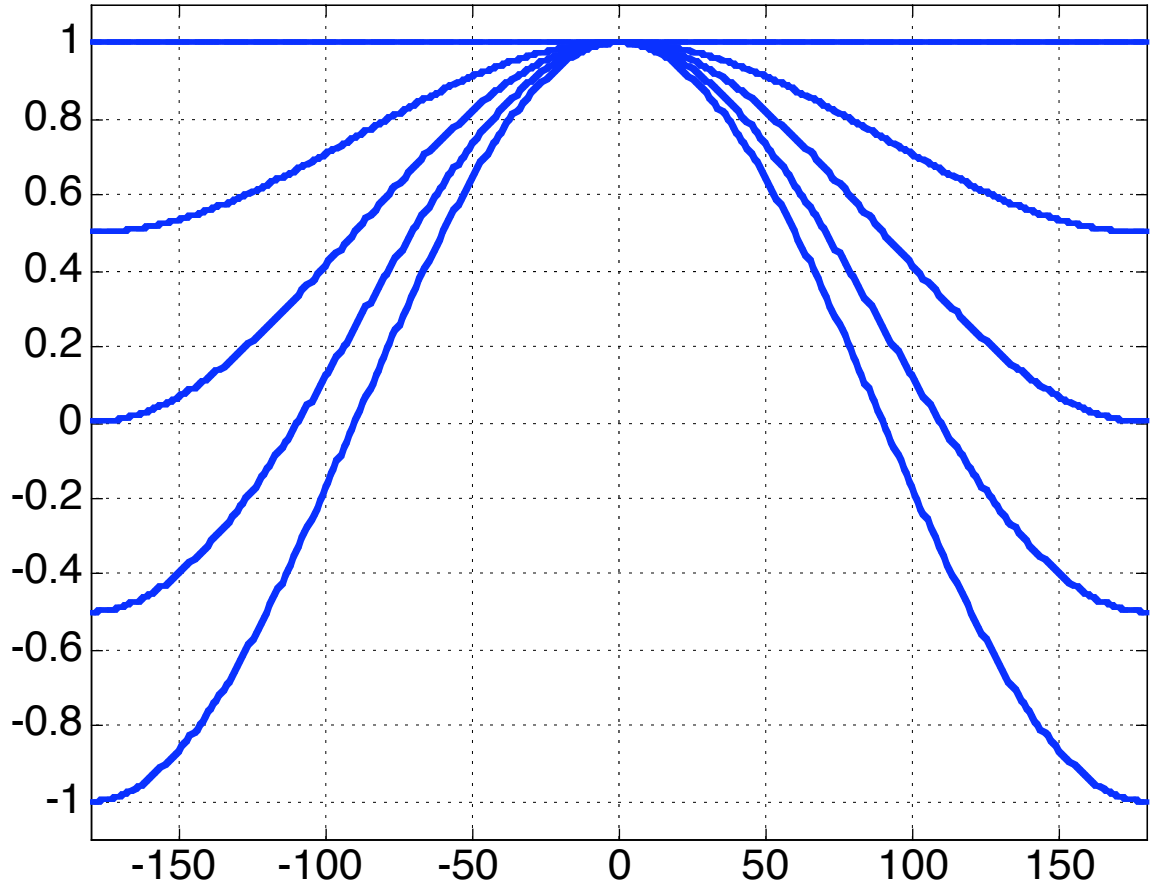
Omnidirectional

Subcardioid

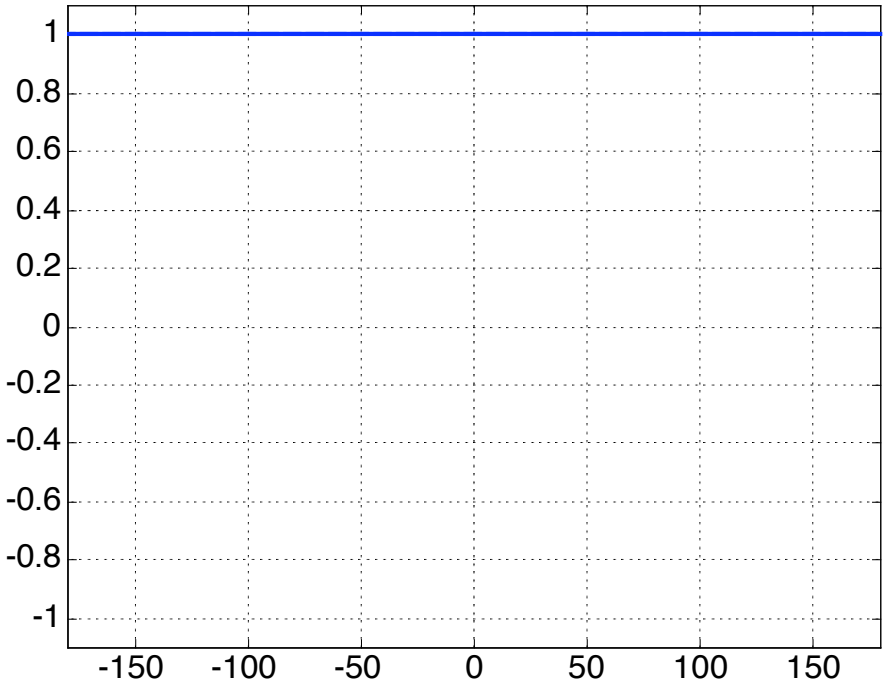
Cardioid

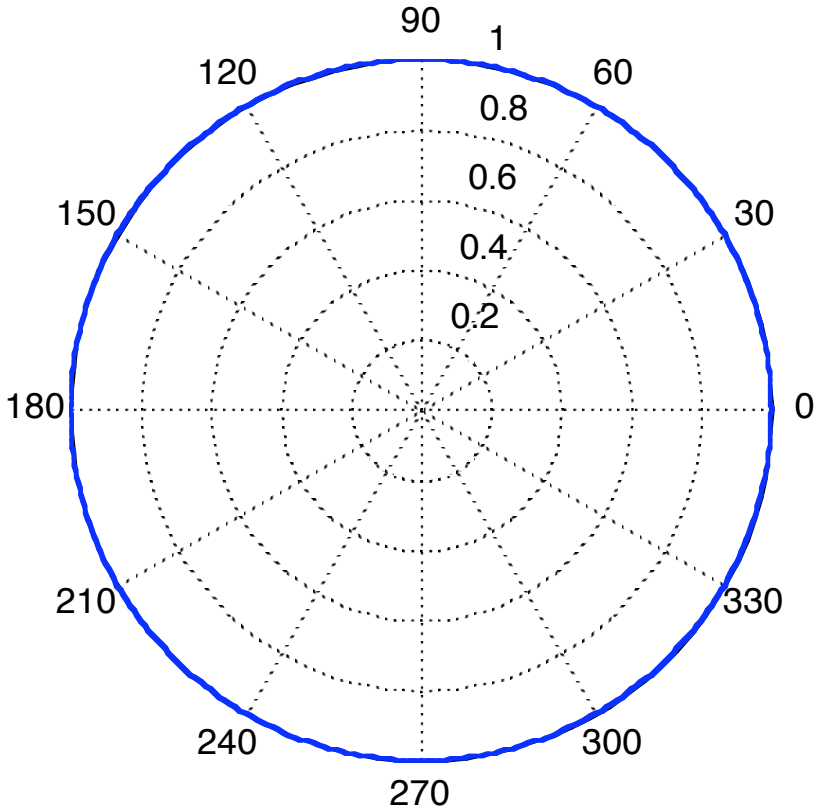
Hypercardioid

Bidirectional

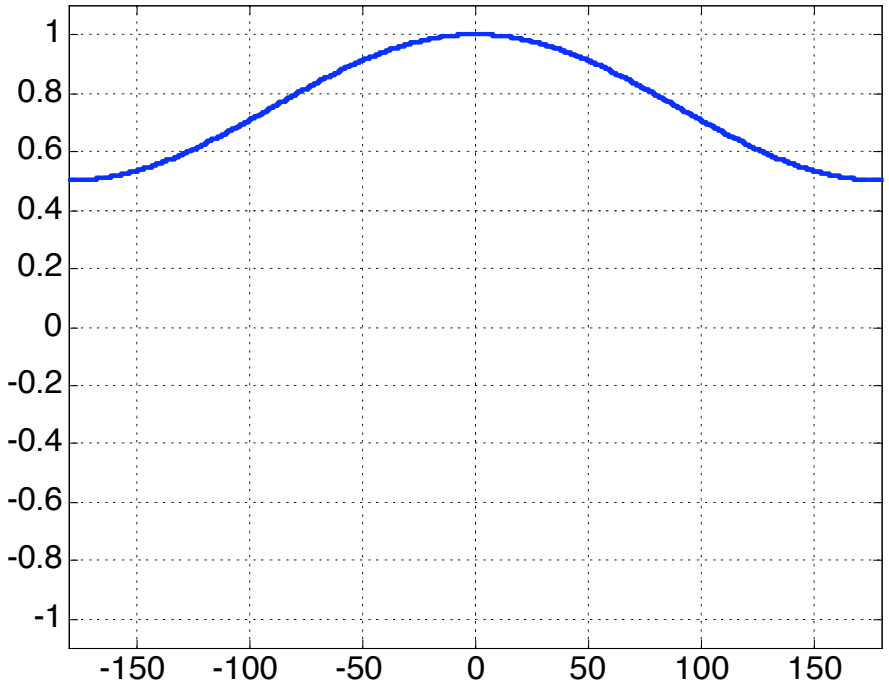


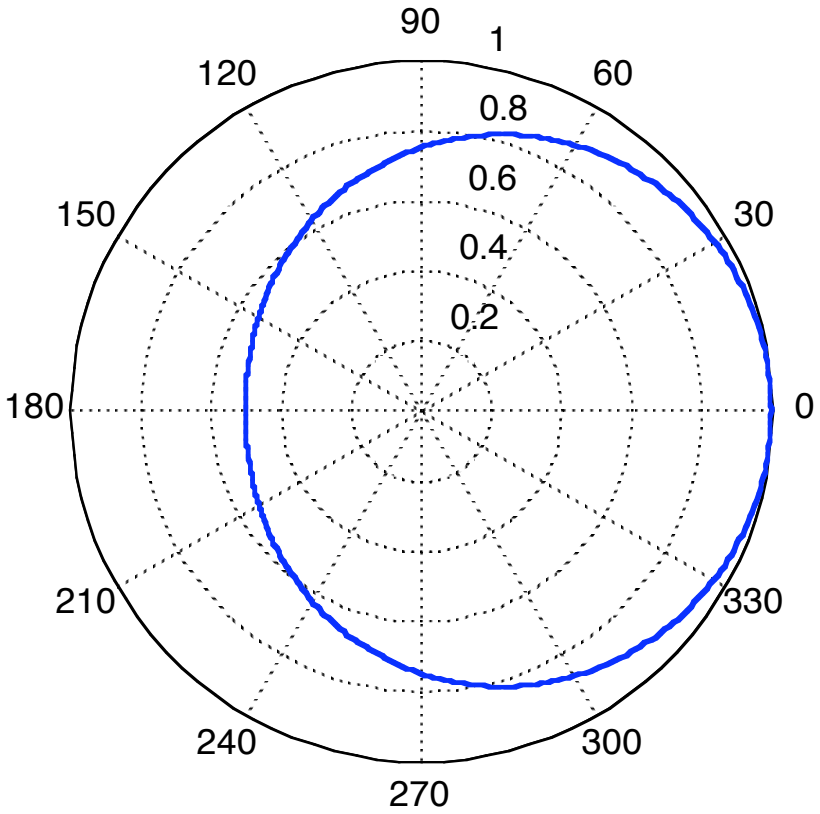
Omnidirectional



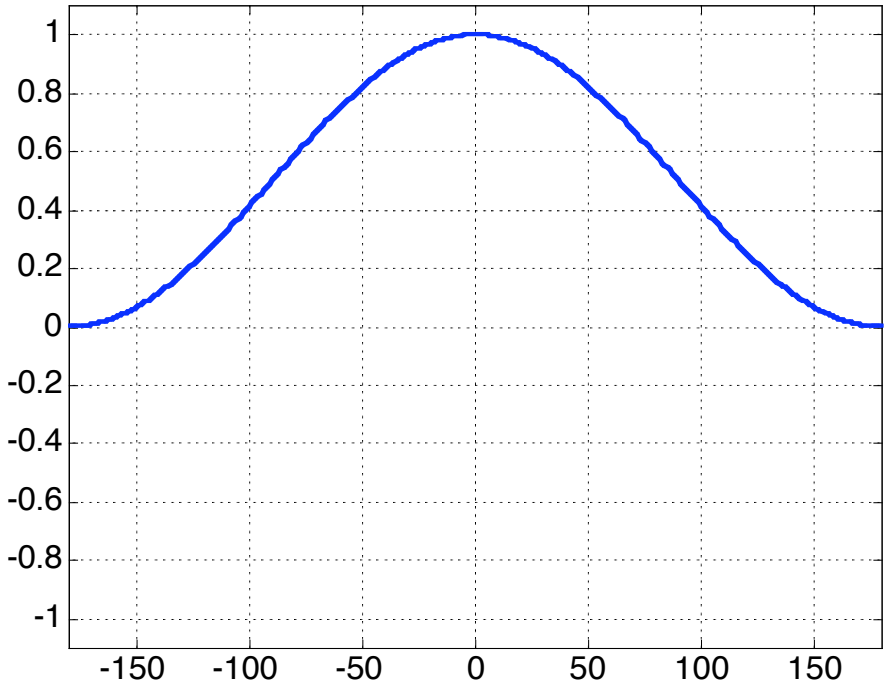


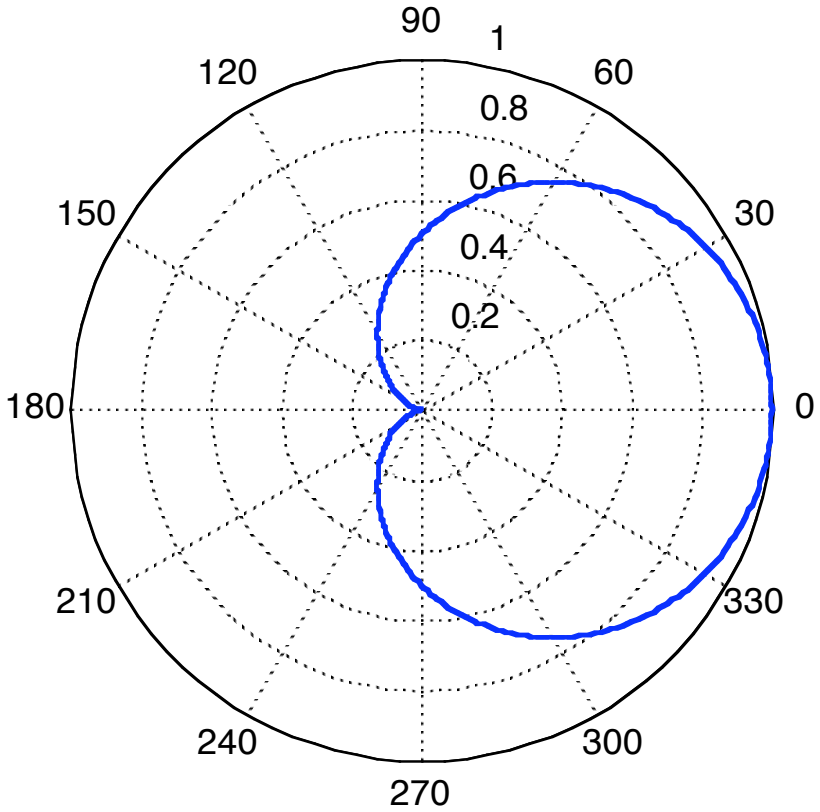
Subcardioid



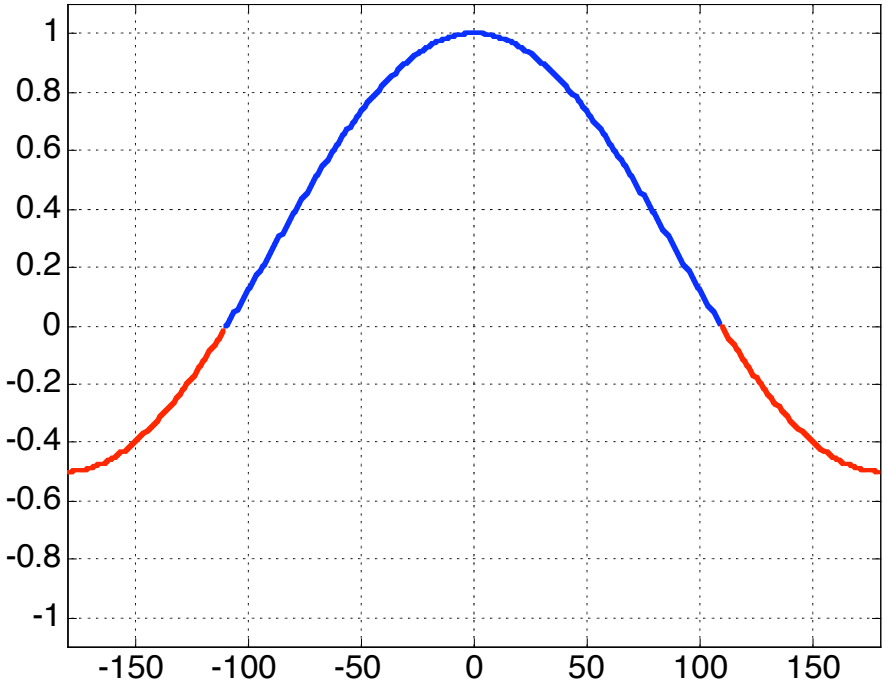


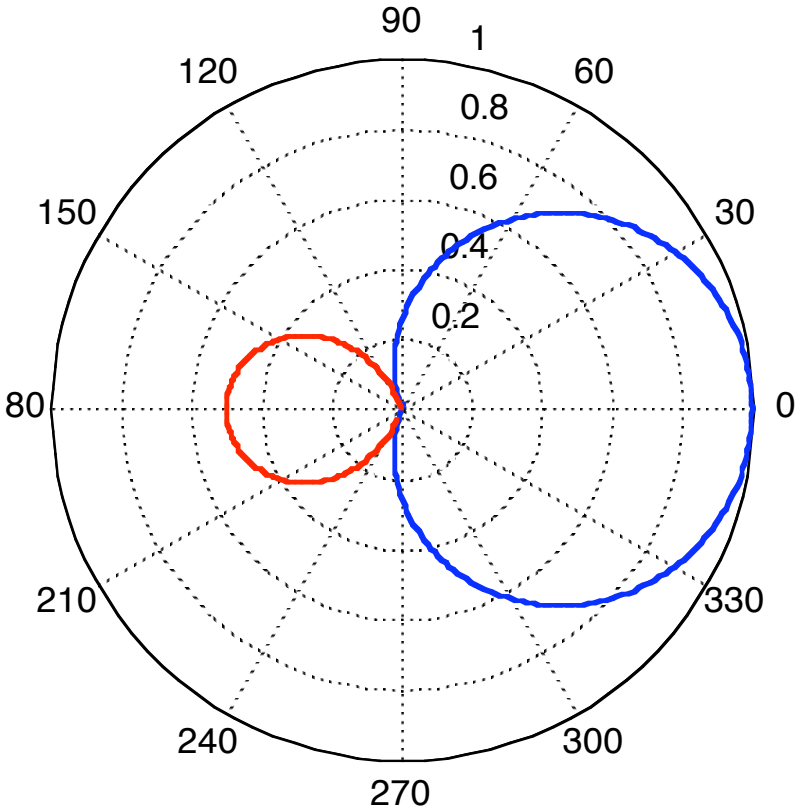
Cardioid


1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-150
-100
-50
0
50
100
150

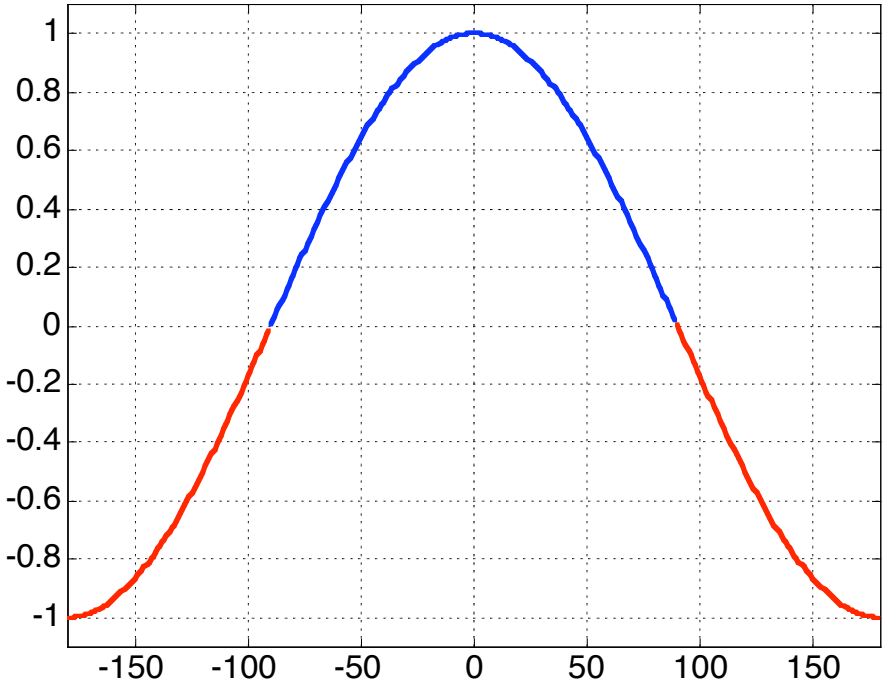

90
1
120
60
0.8
0.6
150
30
0.4
0.2
180
0
210
330
240
300
270

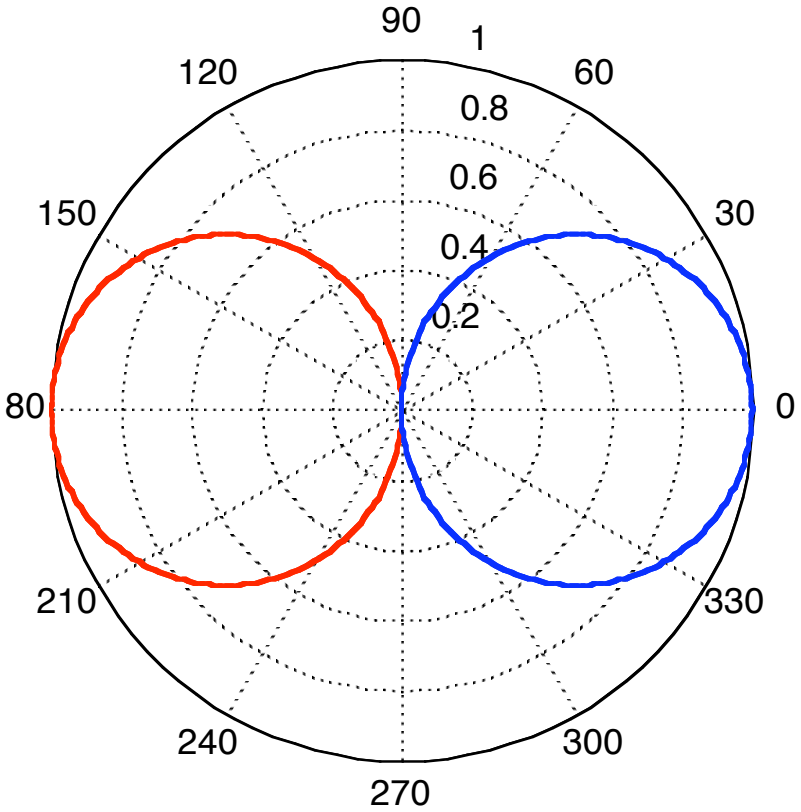
Hypercardioid





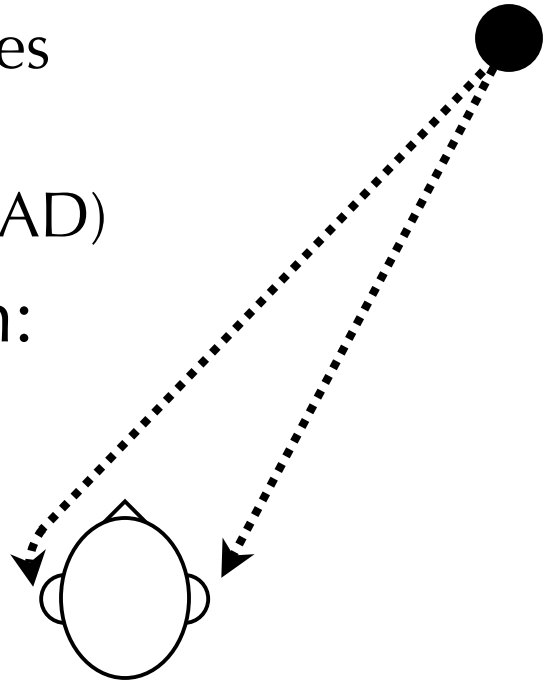
Bidirectional





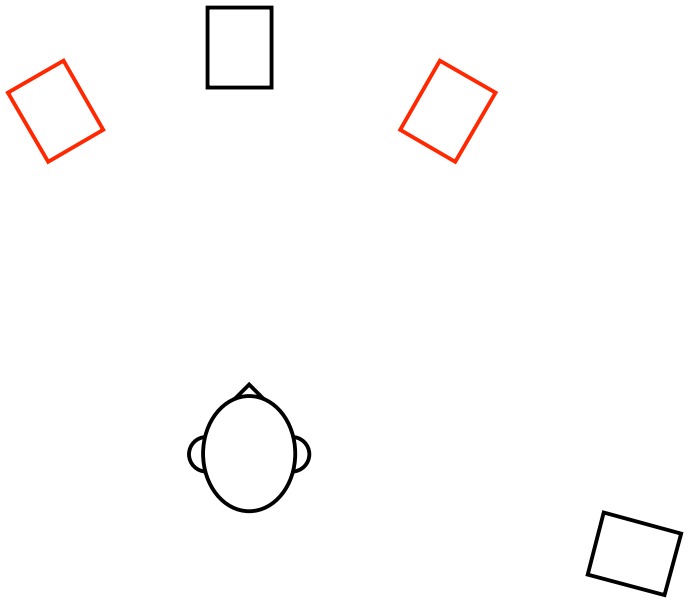
Localisation in the real world

- Left-right localisation relies on:
  - Interaural time of arrival differences (ITD)
  - Interaural amplitude differences (IAD)
- Front-back localisation relies on:
  - Head rotation cues
  - Reflections off the pinnae
  - Shoulder reflections



Localization in the reproduced world

- Phantom image localization relies on:
  - Interchannel amplitude differences
  - Interchannel time differences

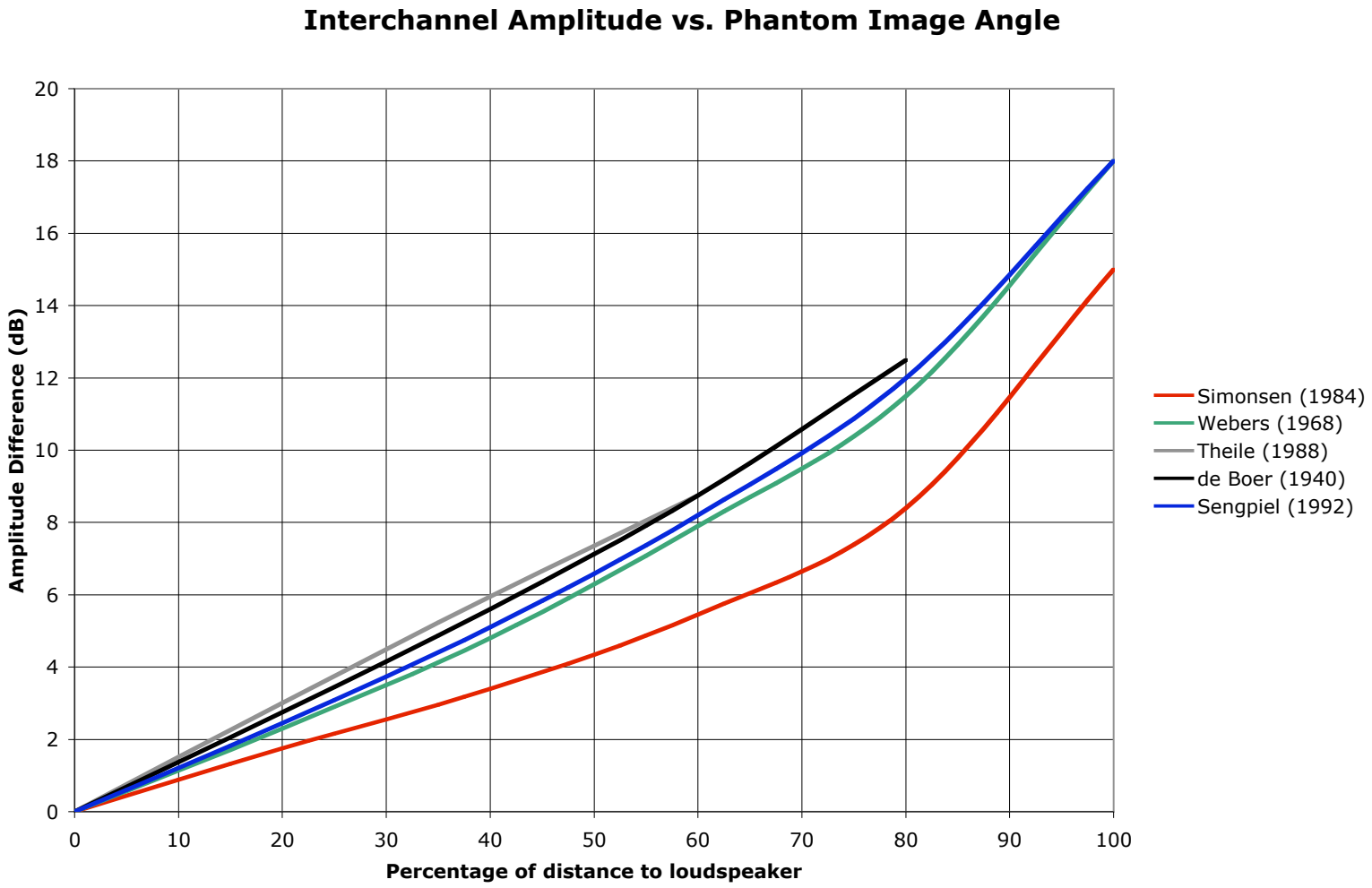


One version…

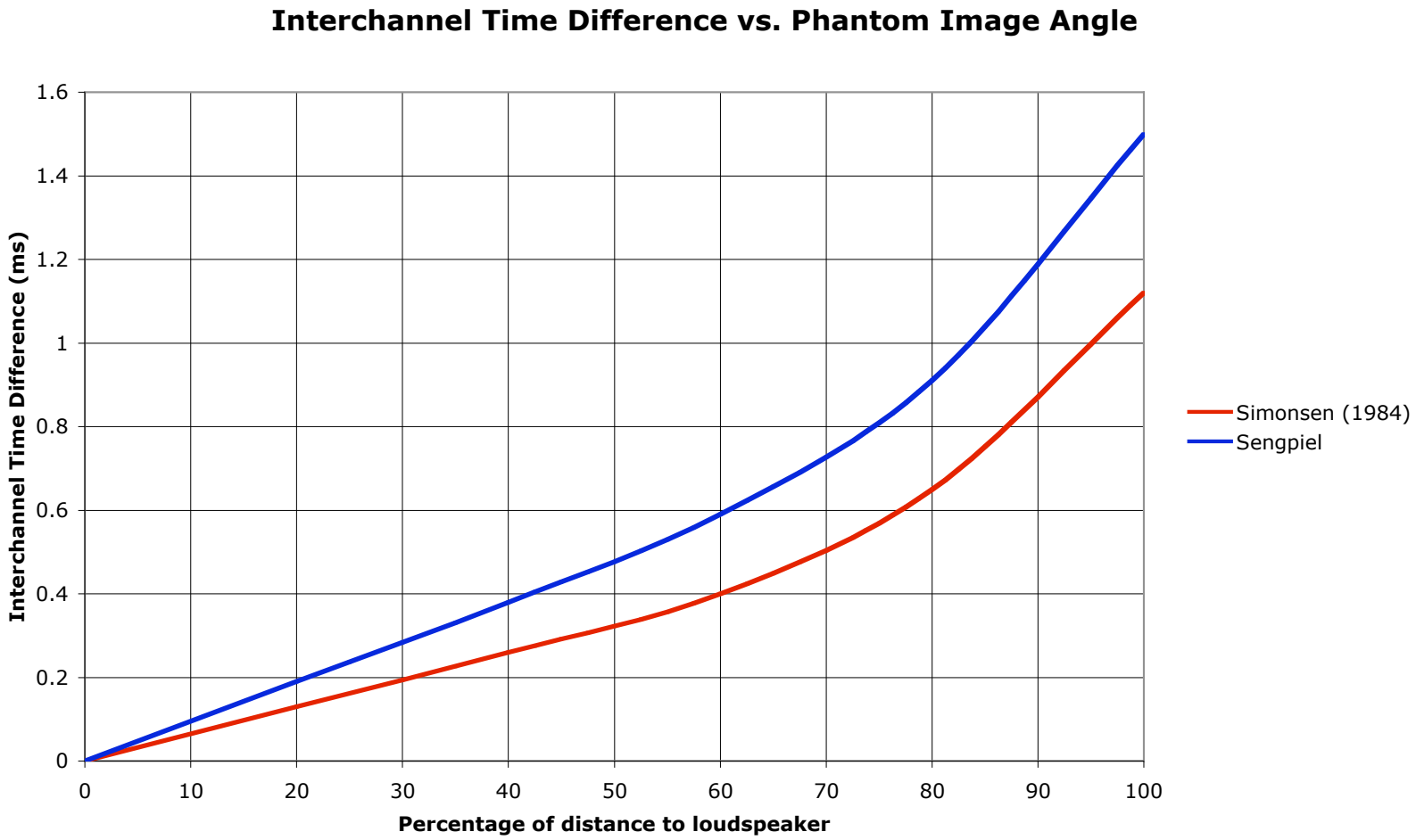
Image position	**Δ Amp.**	**or**	**Δ Time**
0°	0.0 dB	or	0.0 ms
10°	2.5 dB	or	0.2 ms
20°	5.5 dB	or	0.44 ms
30°	15 dB	or	1.12 ms

Gert Simonsen 1983

Other versions…



Other versions…

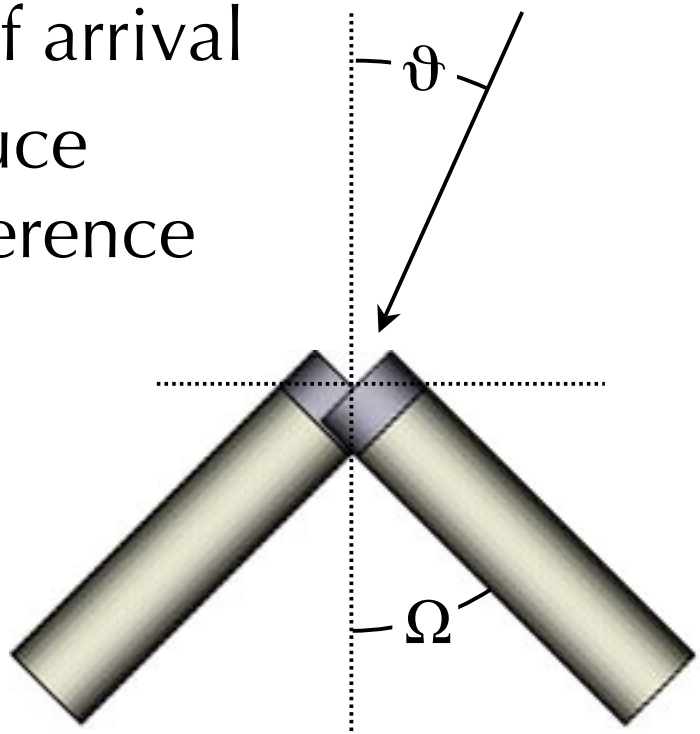


Coincident Microphones

- We assume identical time of arrival
- Sensitivity differences produce interchannel amplitude difference

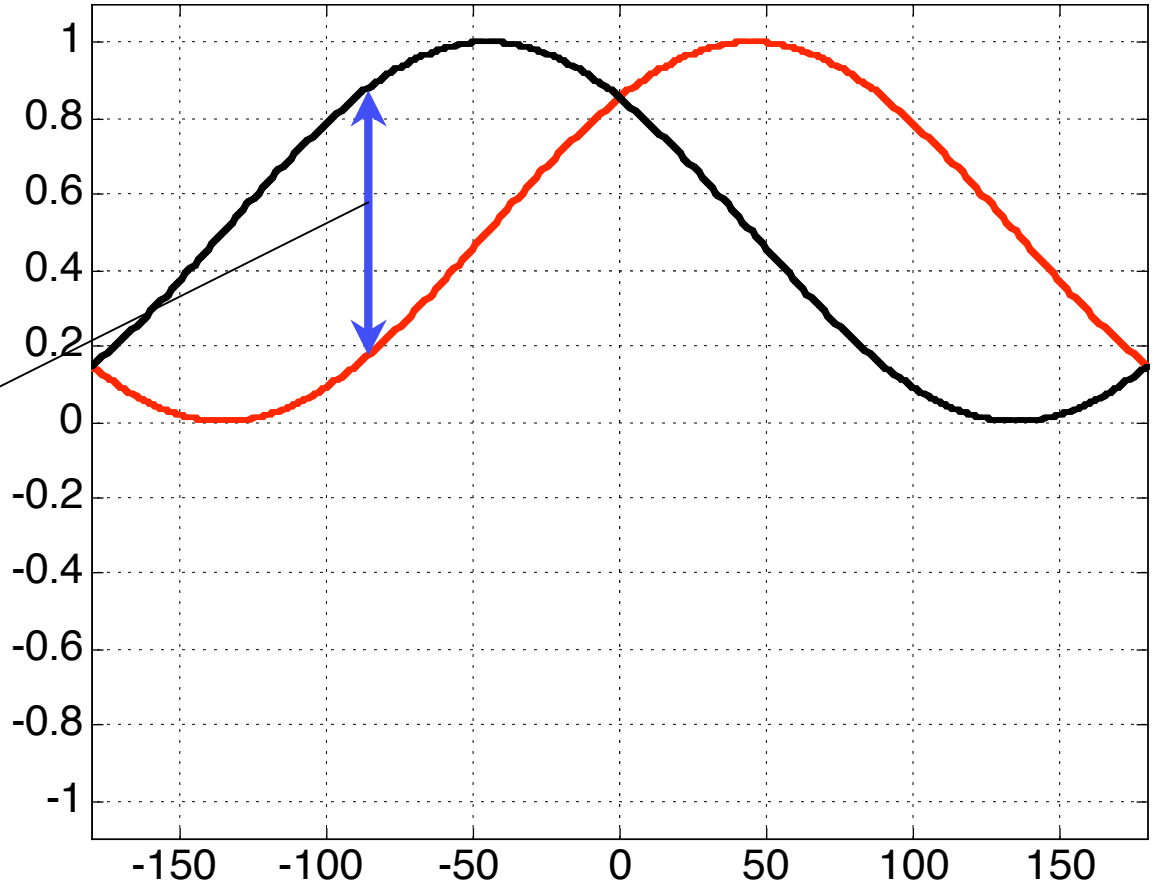
$$S_n = P_n + G_n \cos(\vartheta + \Omega_n)$$

$$DS = 20 \log_{10} \left| \frac{S_1}{S_2} \right|$$

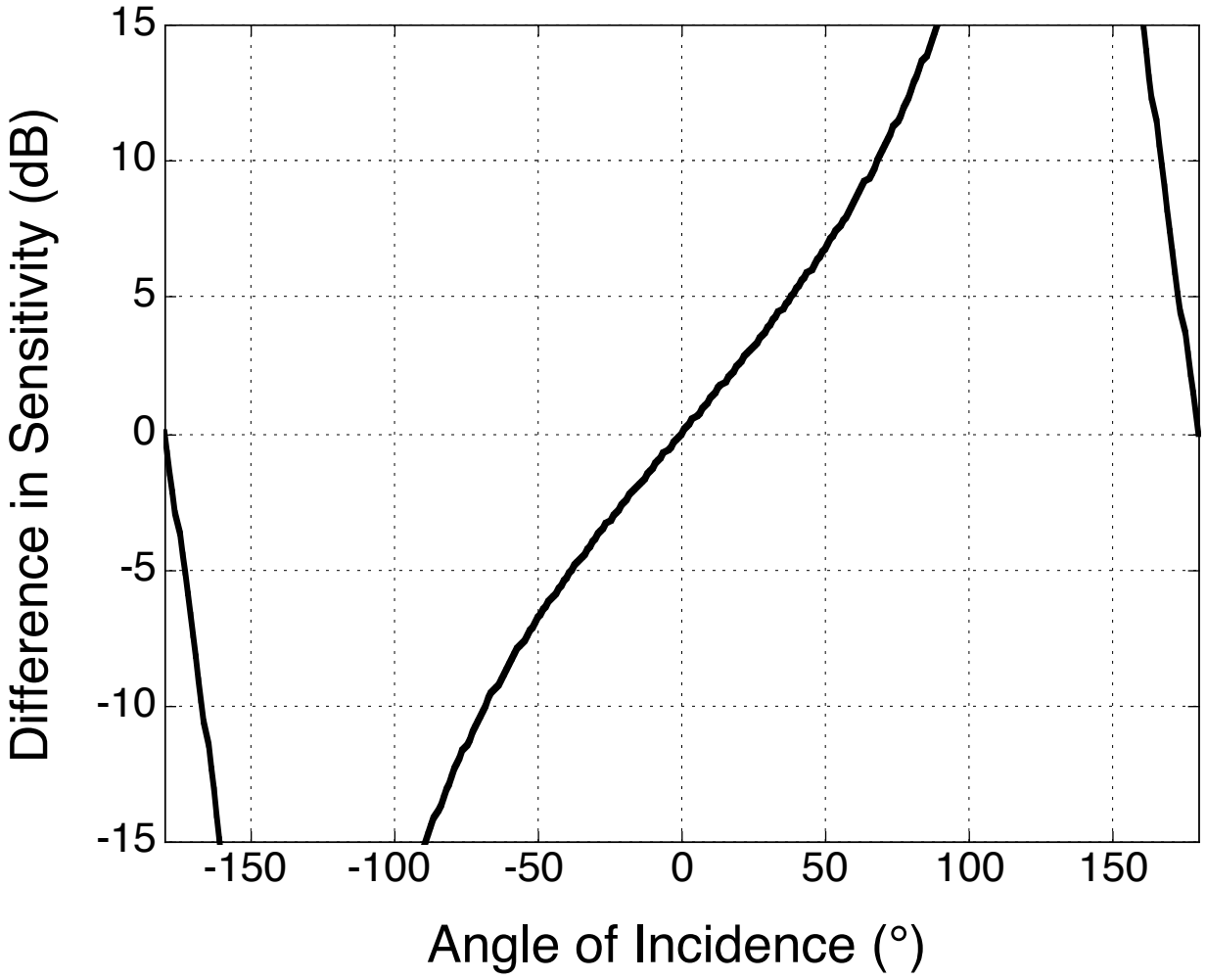


90° Cardioids - Sensitivity Difference

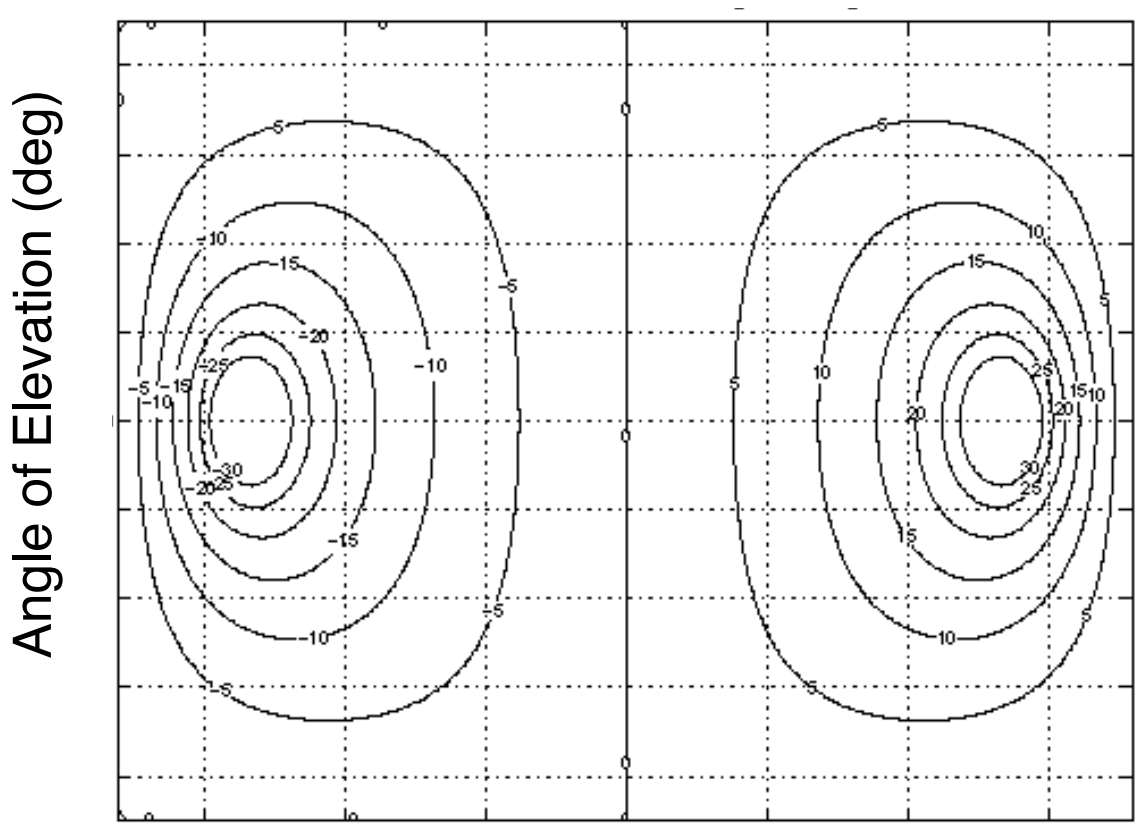
Difference in Sensitivity



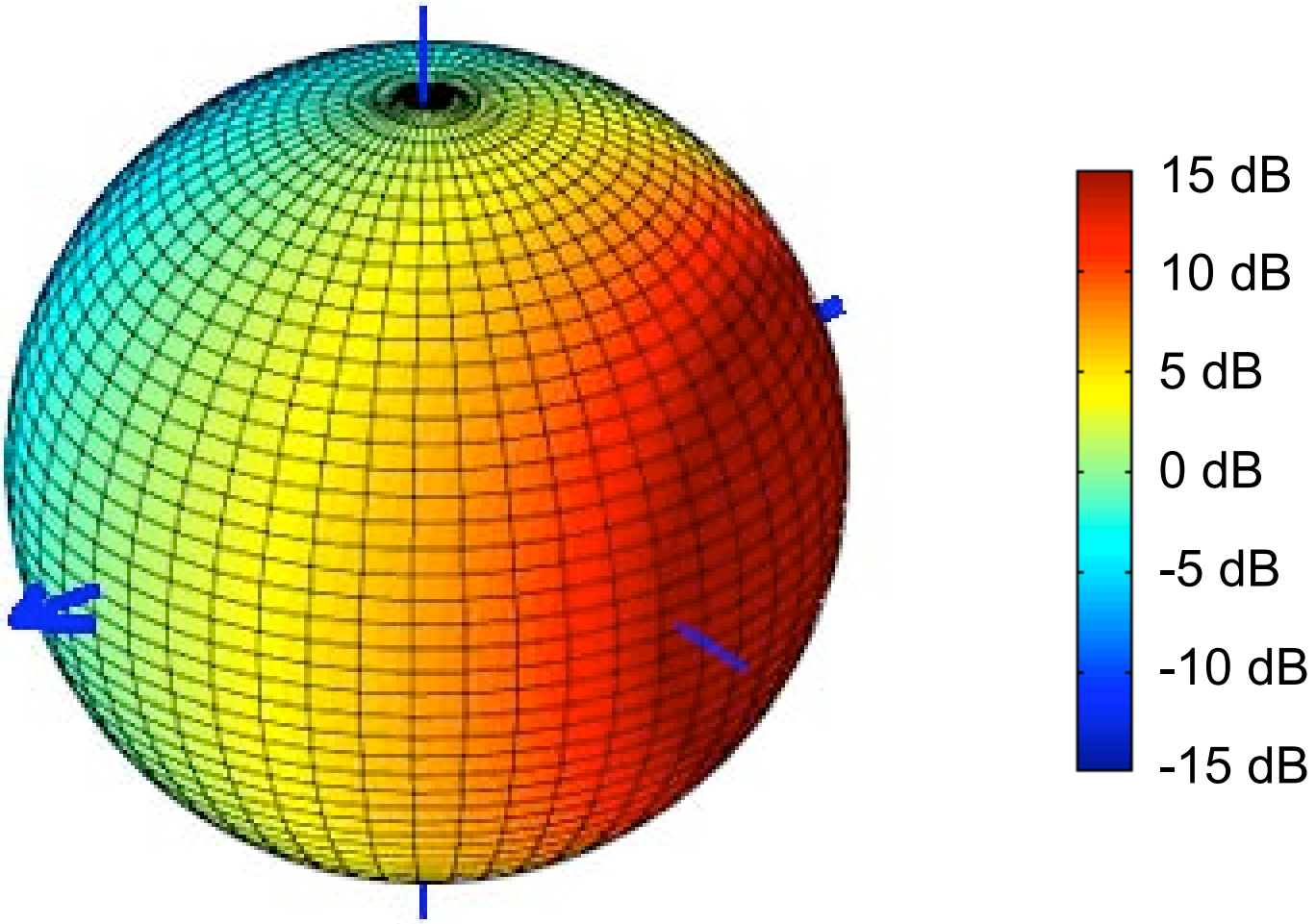
90° Cardioids - Sensitivity Difference



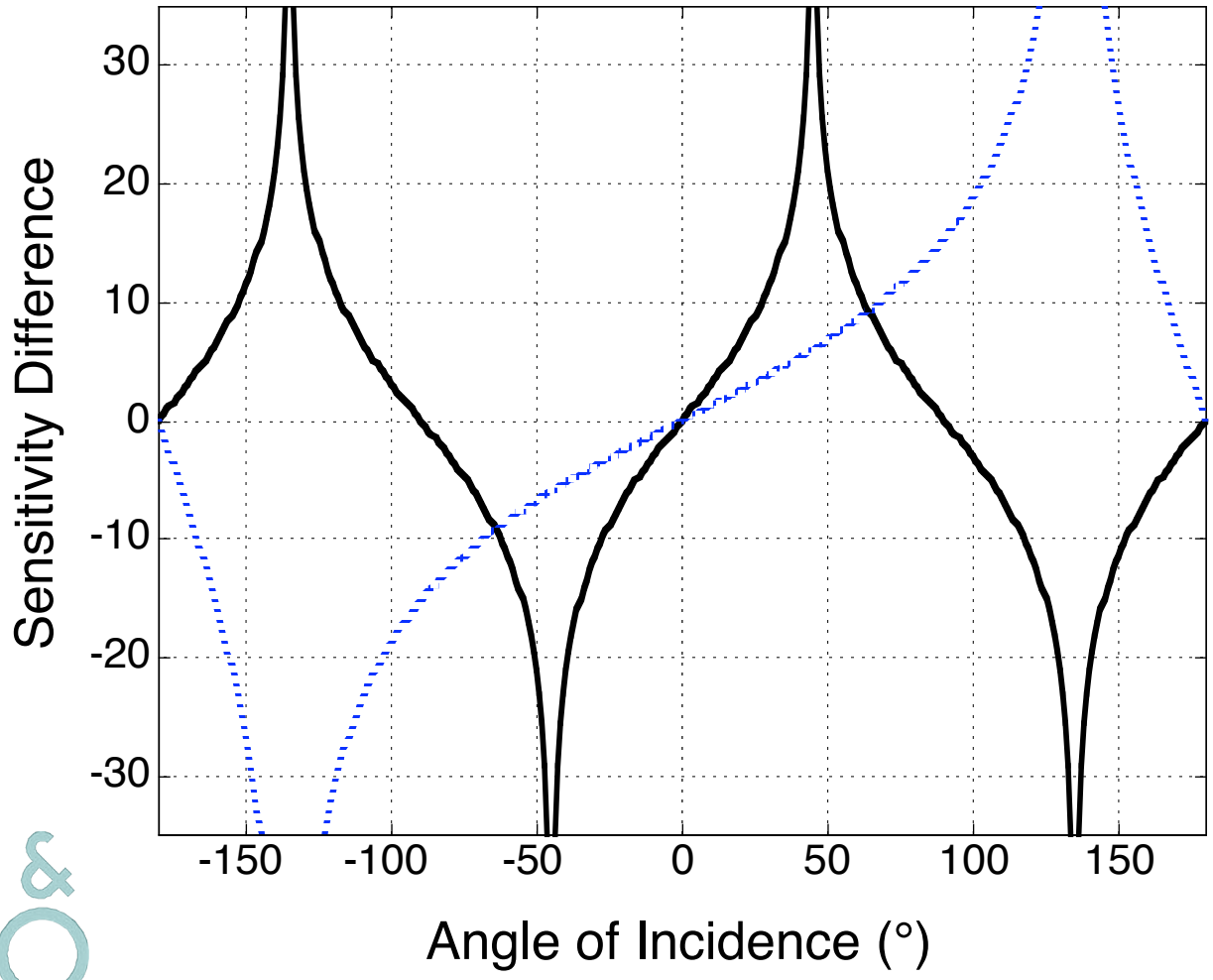
90° Cardioids - Sensitivity Difference



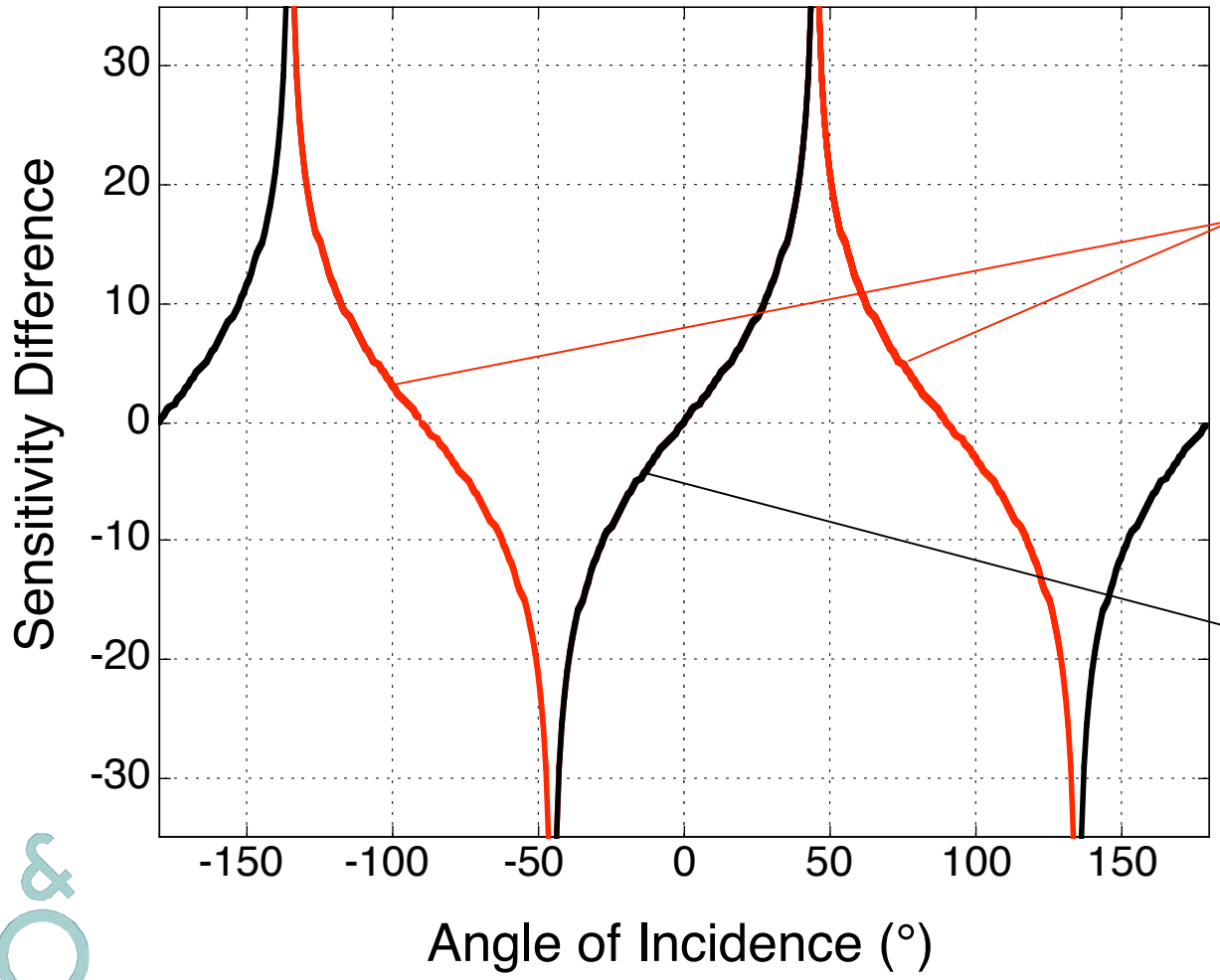
90° Cardioids - Sensitivity Difference



90° Bidirectionals - Sensitivity Difference



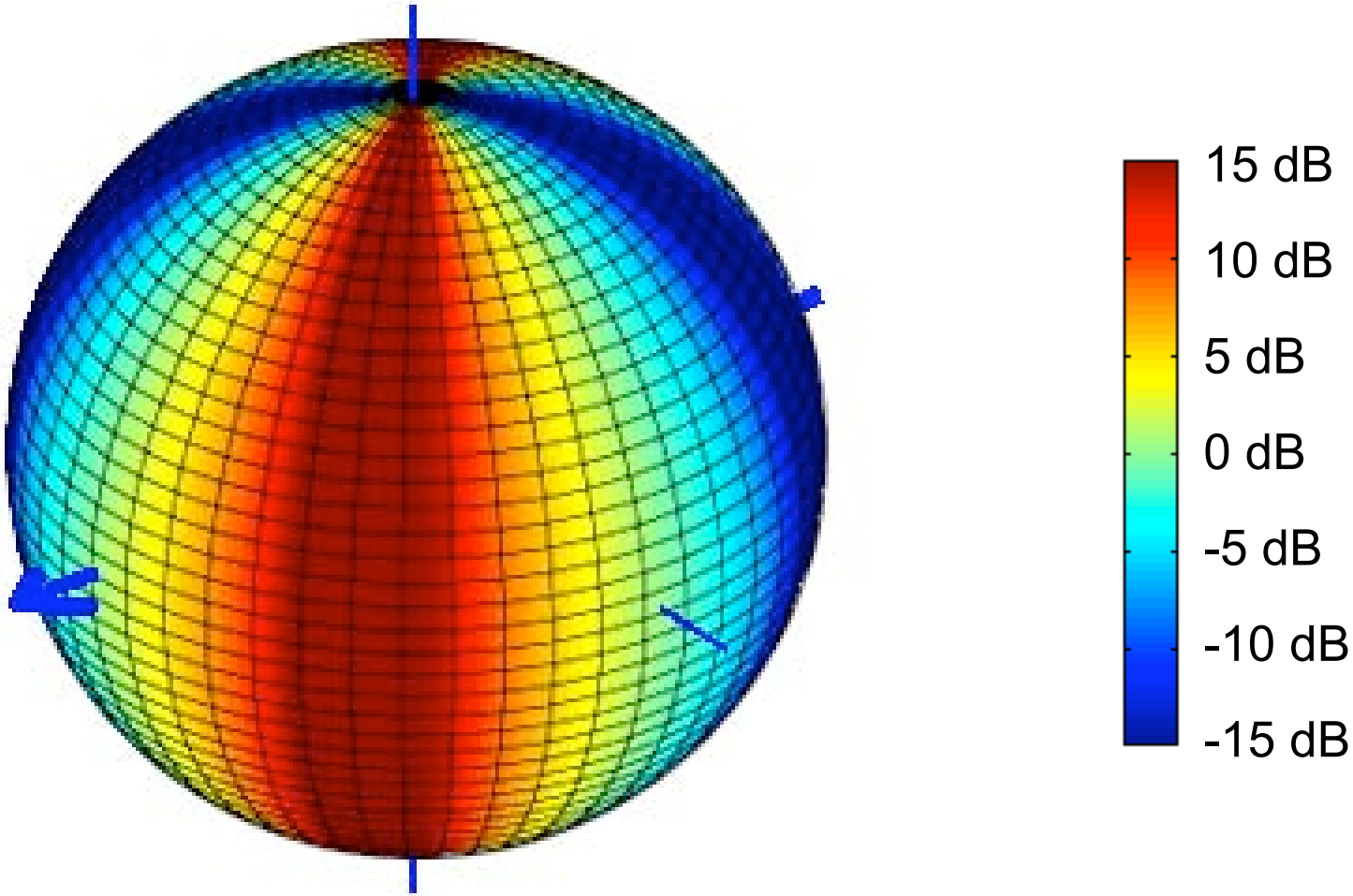
90° Bidirectionals - Sensitivity Difference



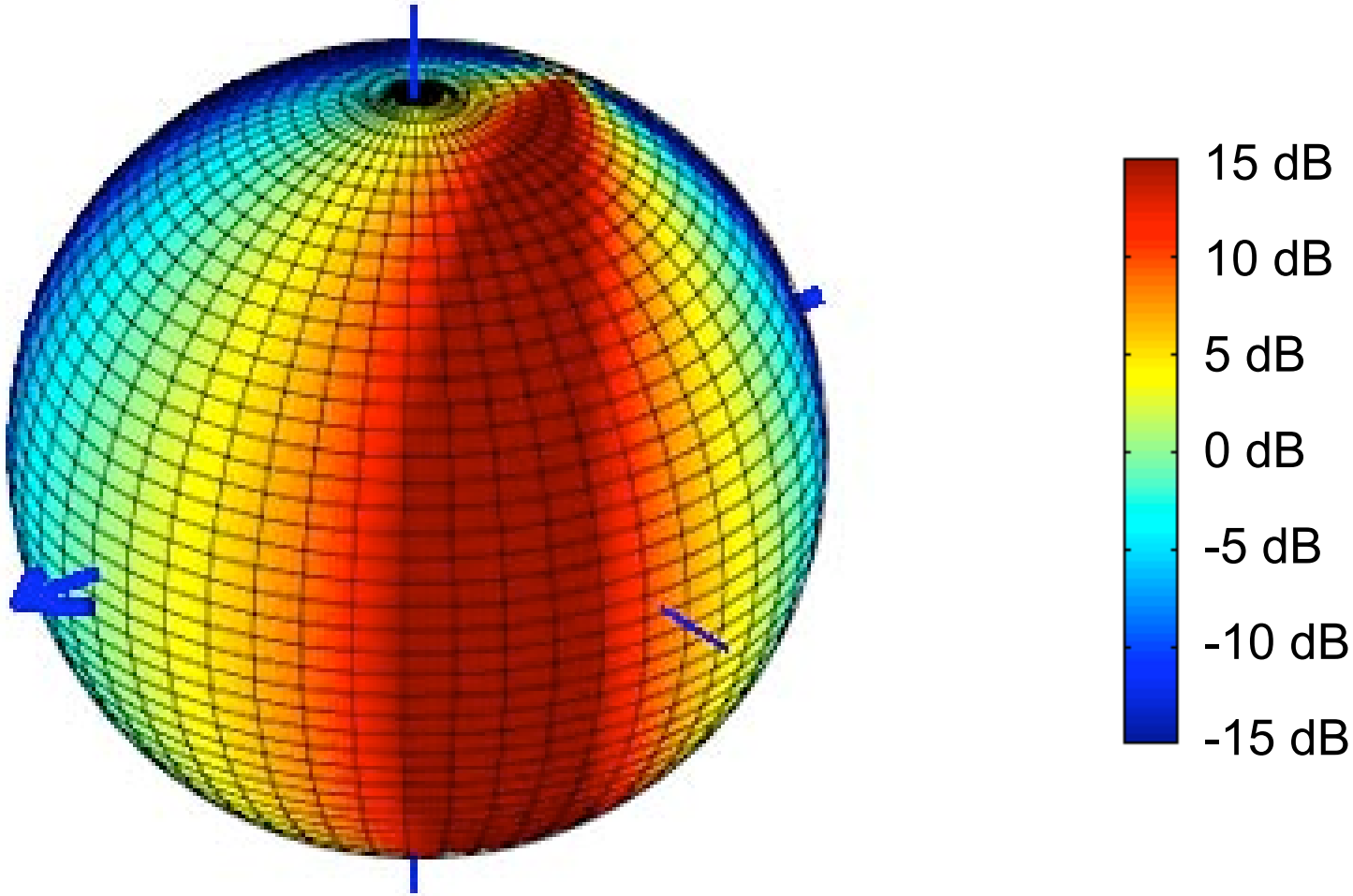
Opposite Polarity
("Out of phase")

Same Polarity
("in phase")

90° Bidirectionals - Sensitivity Difference

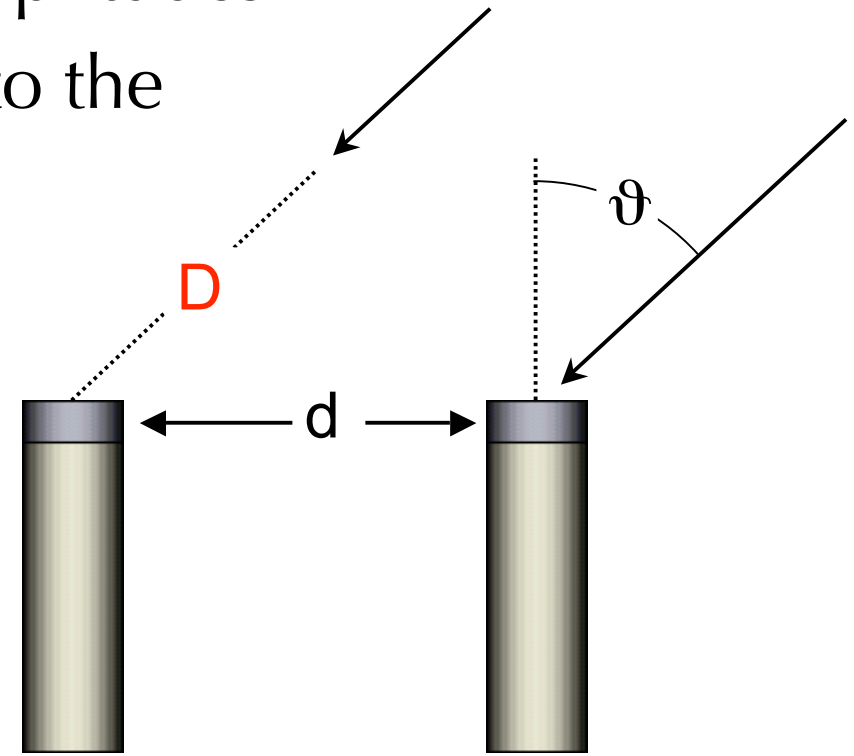


90° Hypercardioids - Sensitivity Difference

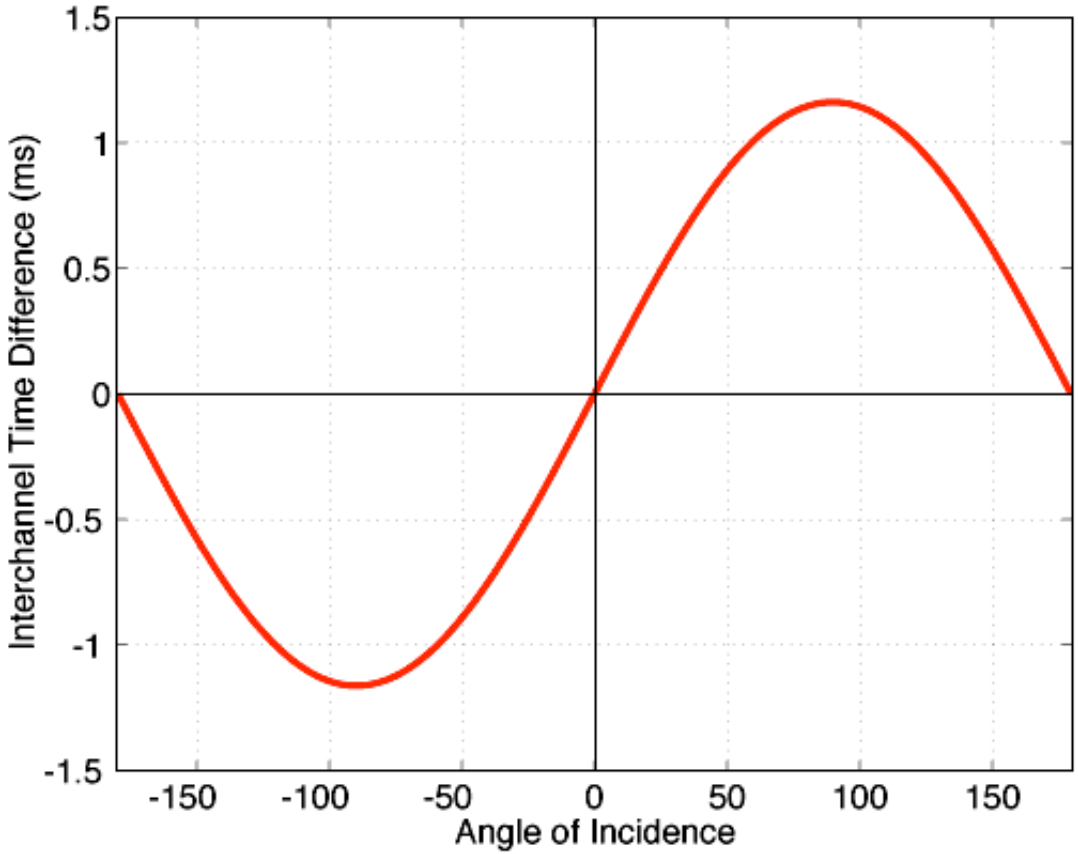


Spaced Omnidirectionals - Time Difference

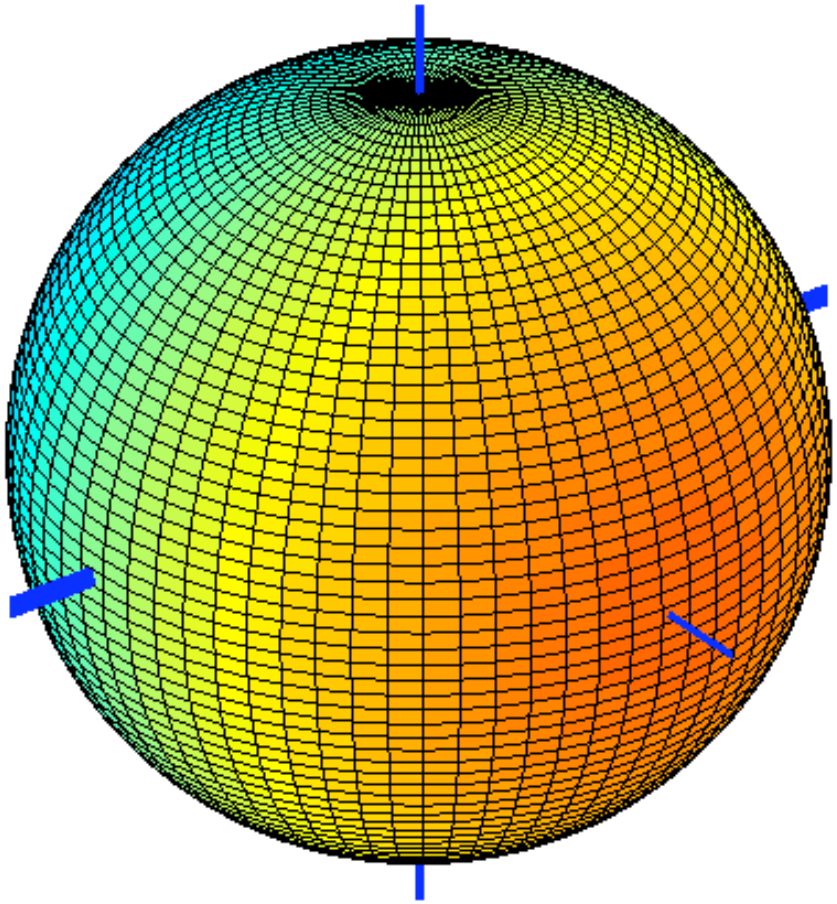
- We assume identical amplitudes
- Differences in distance to the source produce interchannel time difference
- $D = d \sin \vartheta$
- $\Delta T = D / c$

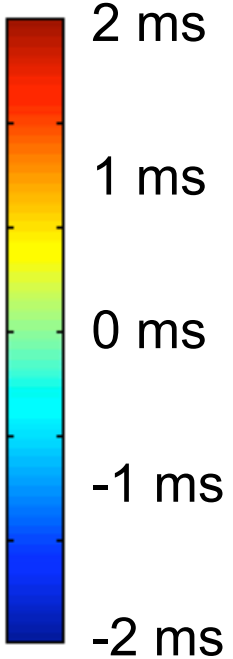


Time difference for 40 cm spacing

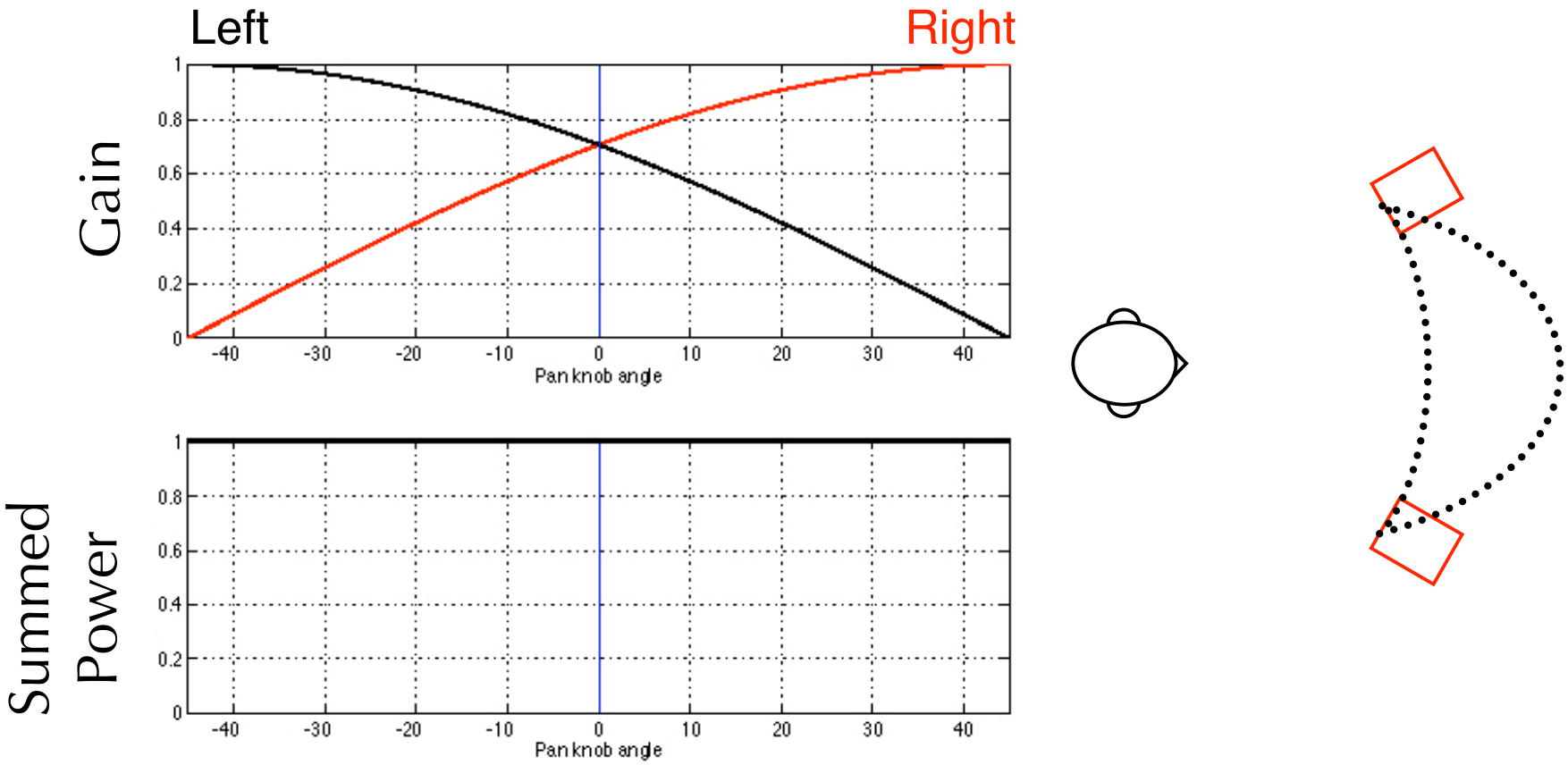


Time difference for 40 cm spacing





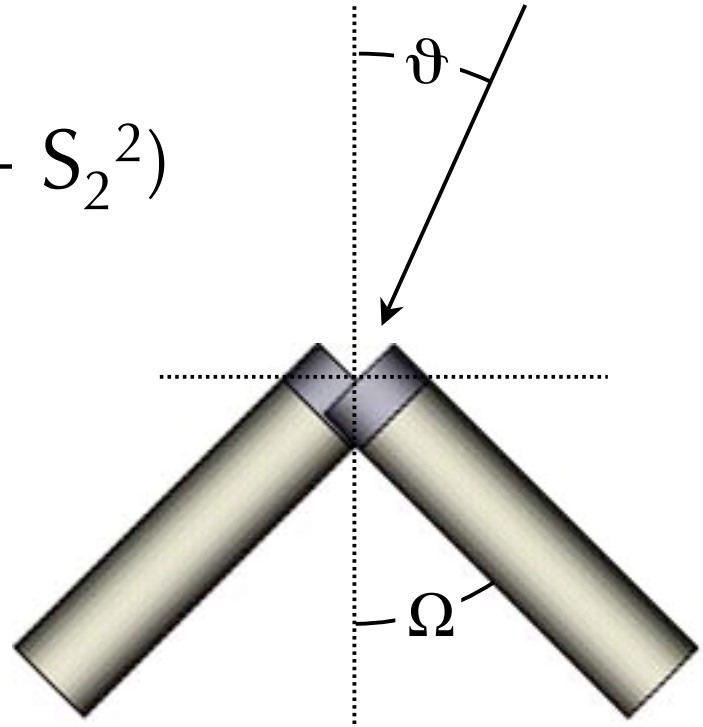
Panning


Left
Right
Gain
1
0.8
0.6
0.4
0.2
0
-40
-30
-20
-10
0
10
20
30
40
Pan knob angle
Summed Power
1
0.8
0.6
0.4
0.2
0
-40
-30
-20
-10
0
10
20
30
40
Pan knob angle

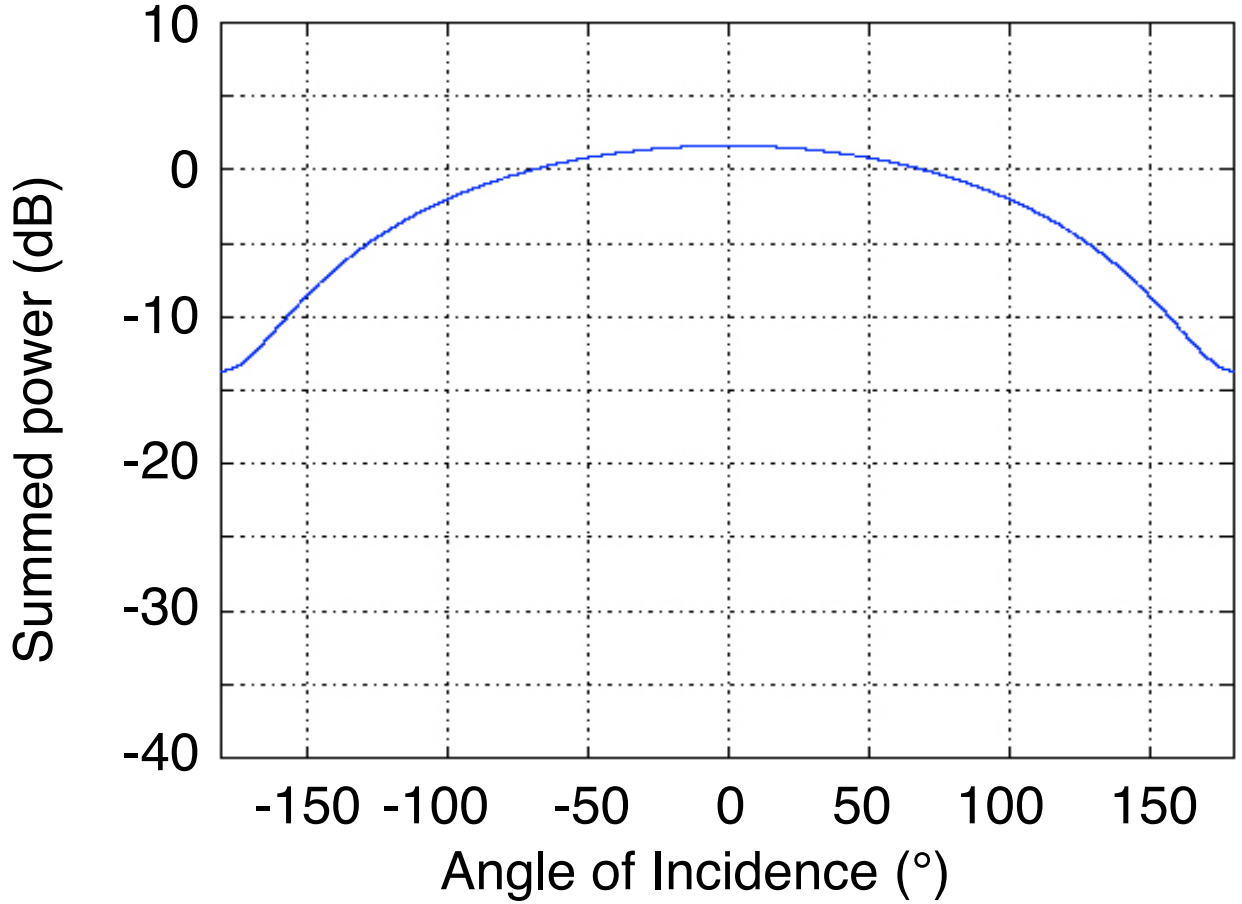
Coincident Microphones - Power Sum

$$S_n = P_n + G_n \cos(\vartheta + \Omega_n)$$

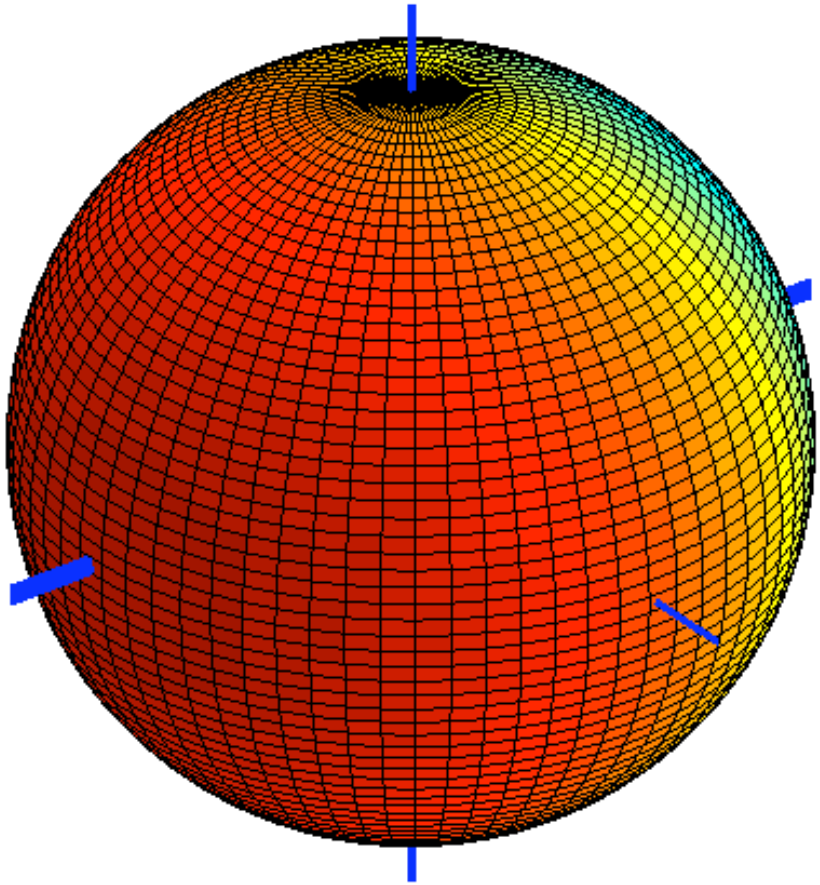
$$S \text{ Power} = 10 \log_{10} (S_1^2 + S_2^2)$$

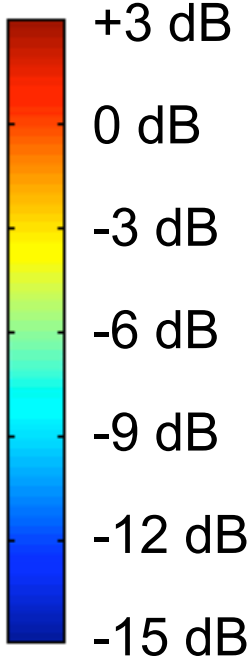


90° Cardioids - Power Sum

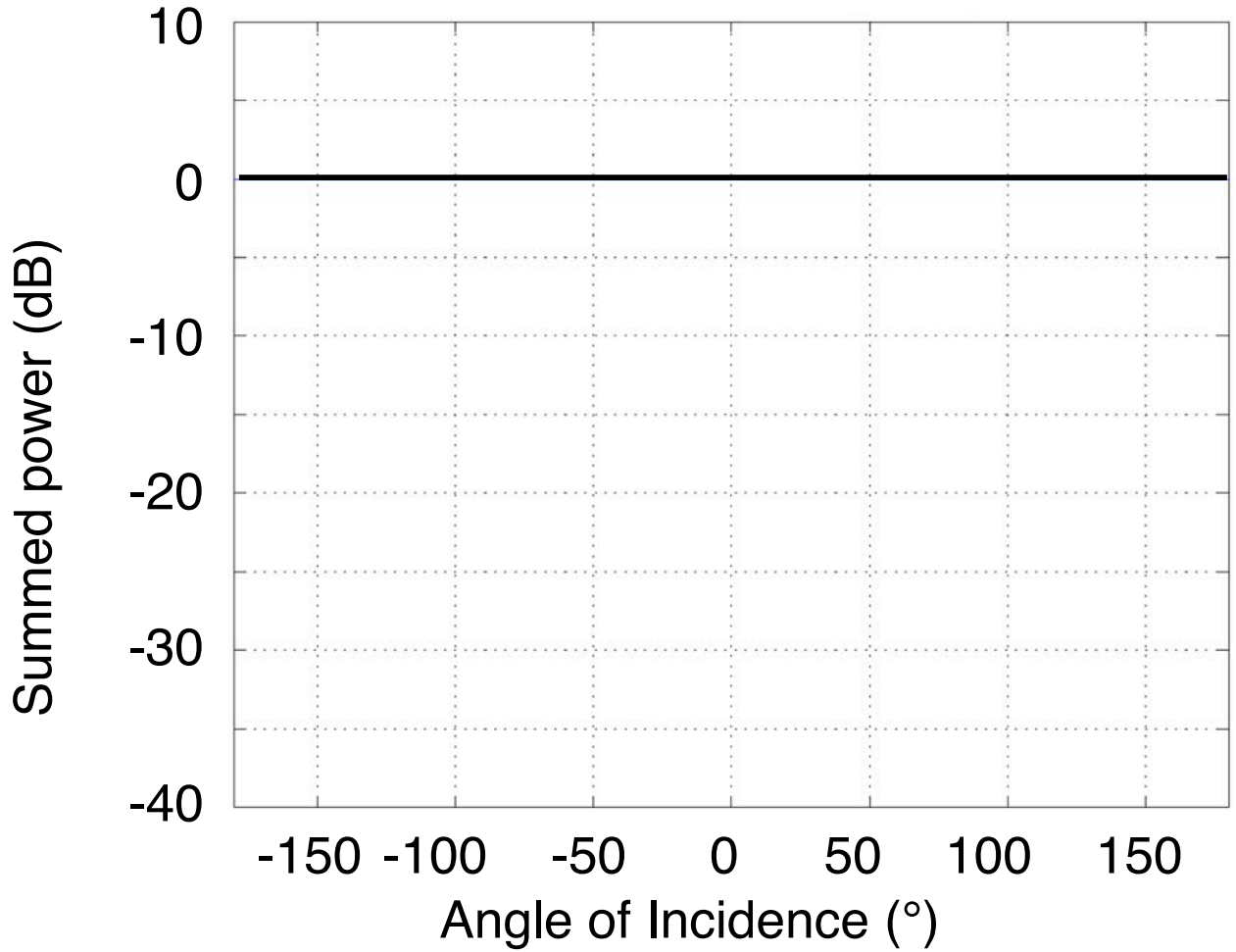


90° Cardioids - Power Sum

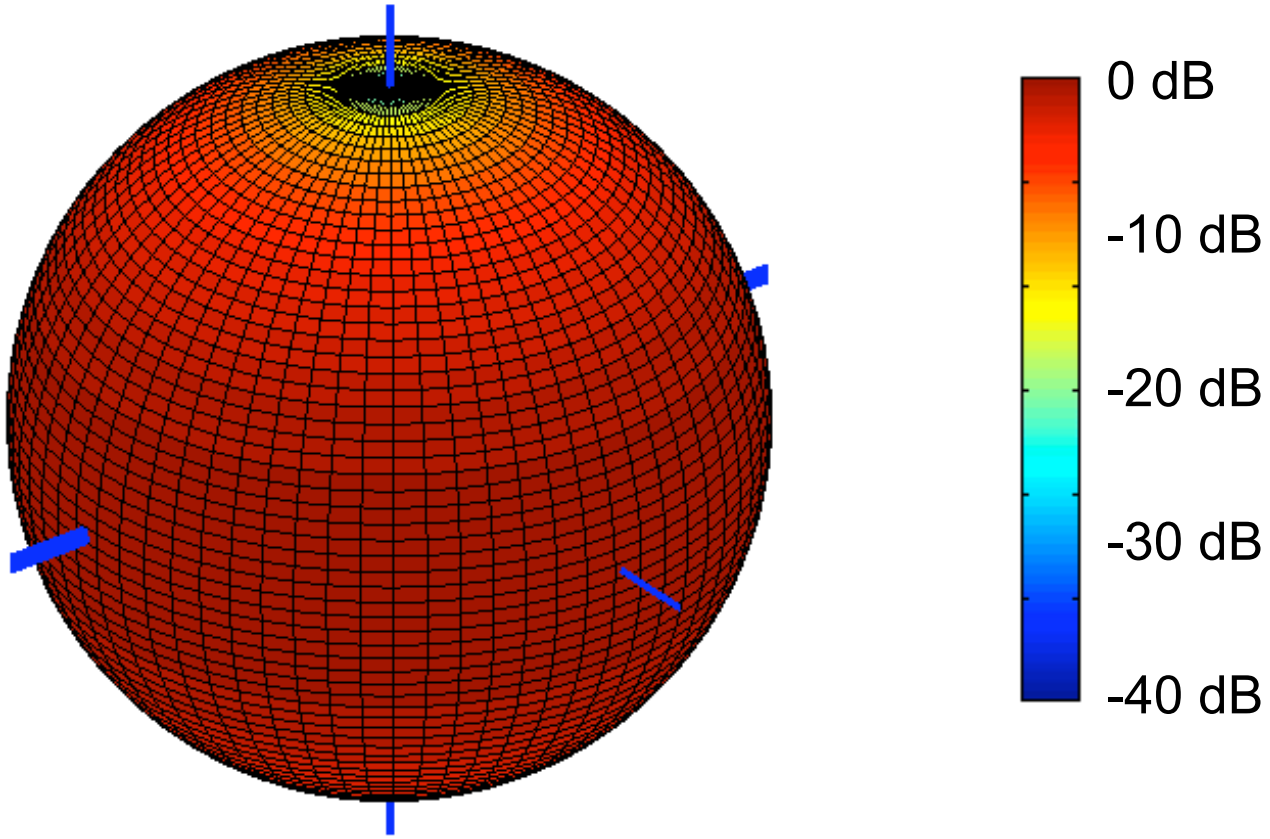




90° Bidirectionals - Power Sum



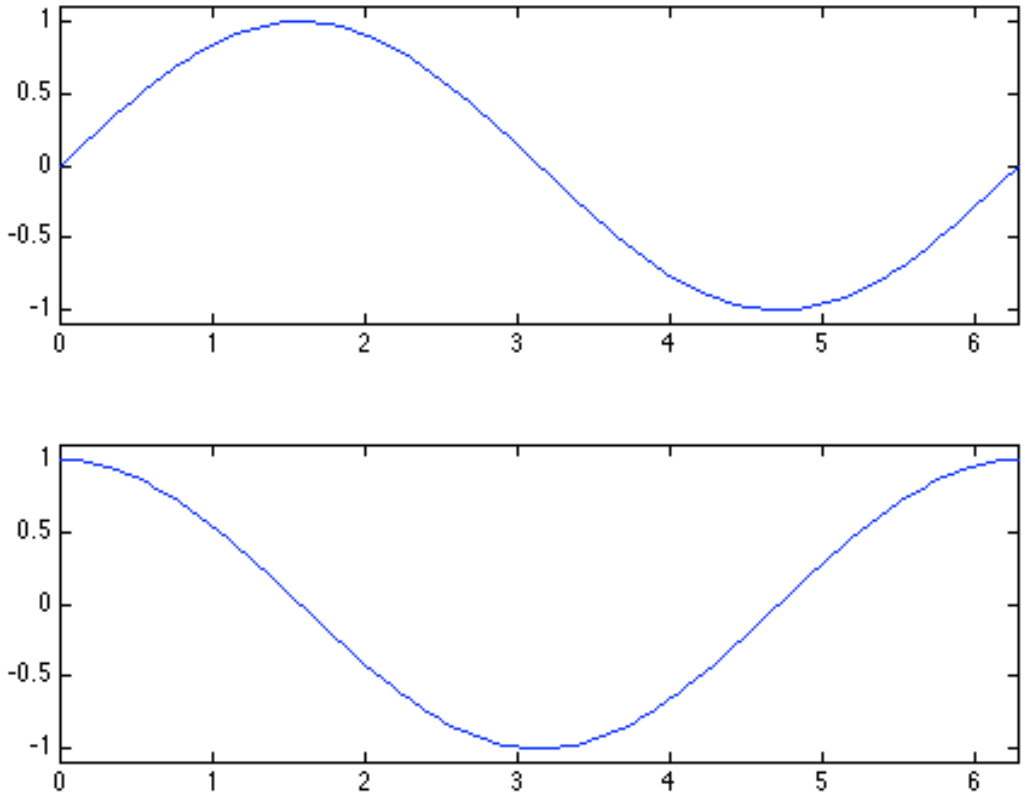
90° Cardioids - Power Sum



Correlation Coefficient

- An indicator of the relationship between two signals
- Positive correlation: if one goes up, so does the other
- Negative Correlation: If one goes up, the other goes down
- Correlation = 0: if one goes up, we don't know what the other will do
- Geeky definition: the covariance divided by the product of the standard deviations

Correlation Coefficient

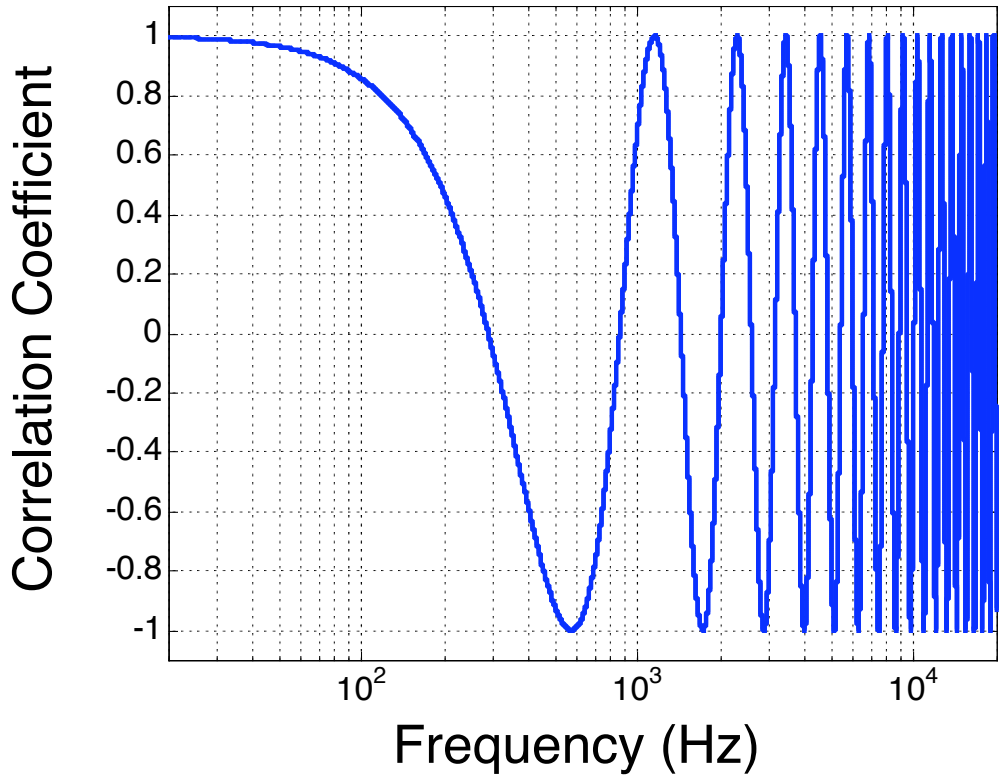


Correlation coefficient
Coincident directional mics, direct sound

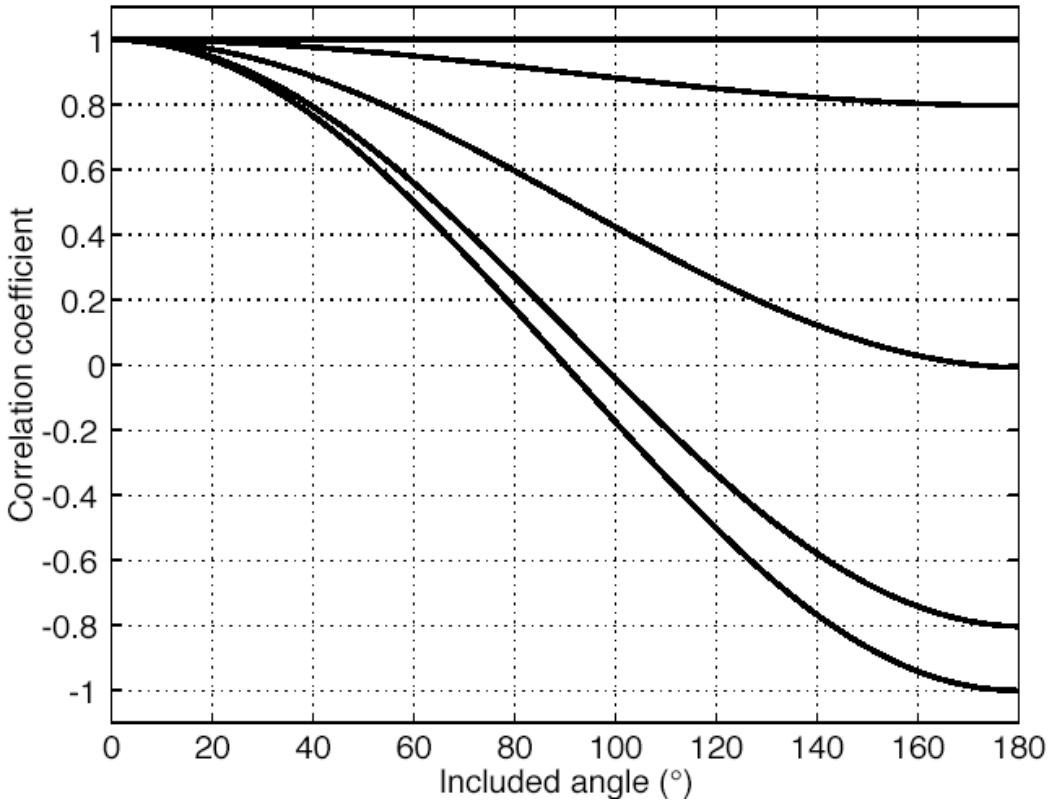
- Coincident mic's have identical time of arrival
- Only differences are:
  - Amplitude
  - Polarity
- Correlation coefficient must be either 1, 0 or -1

Correlation coefficient
Spaced mics, direct sound

- Spaced mic's have different times of arrival
- This results in a phase difference



Correlation coefficient
Coincident directional, diffuse field

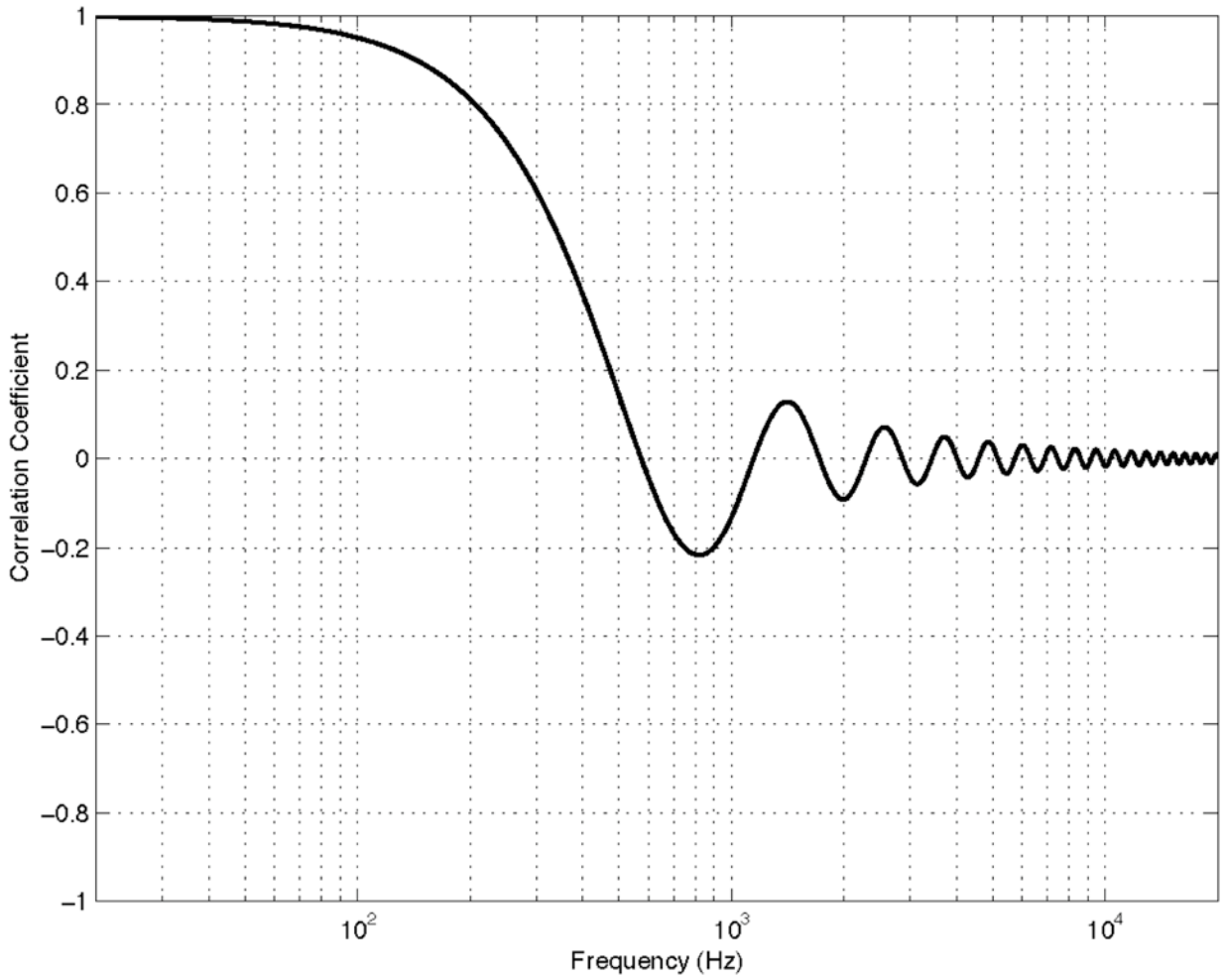


Omni
Subcardioid

Cardioid

Hypercardioid
Bidirectional

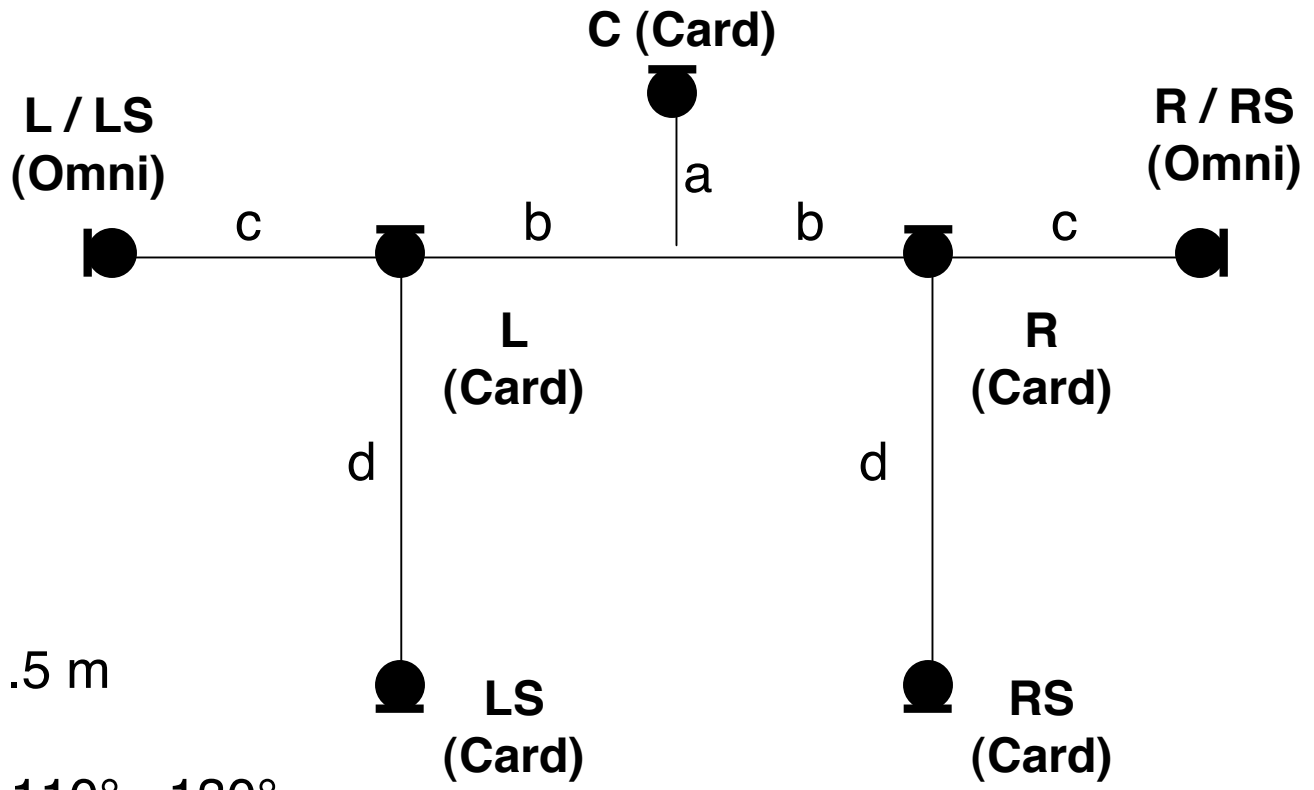
Correlation coefficient
30 cm spaced omni's in a diffuse field



Conclusions

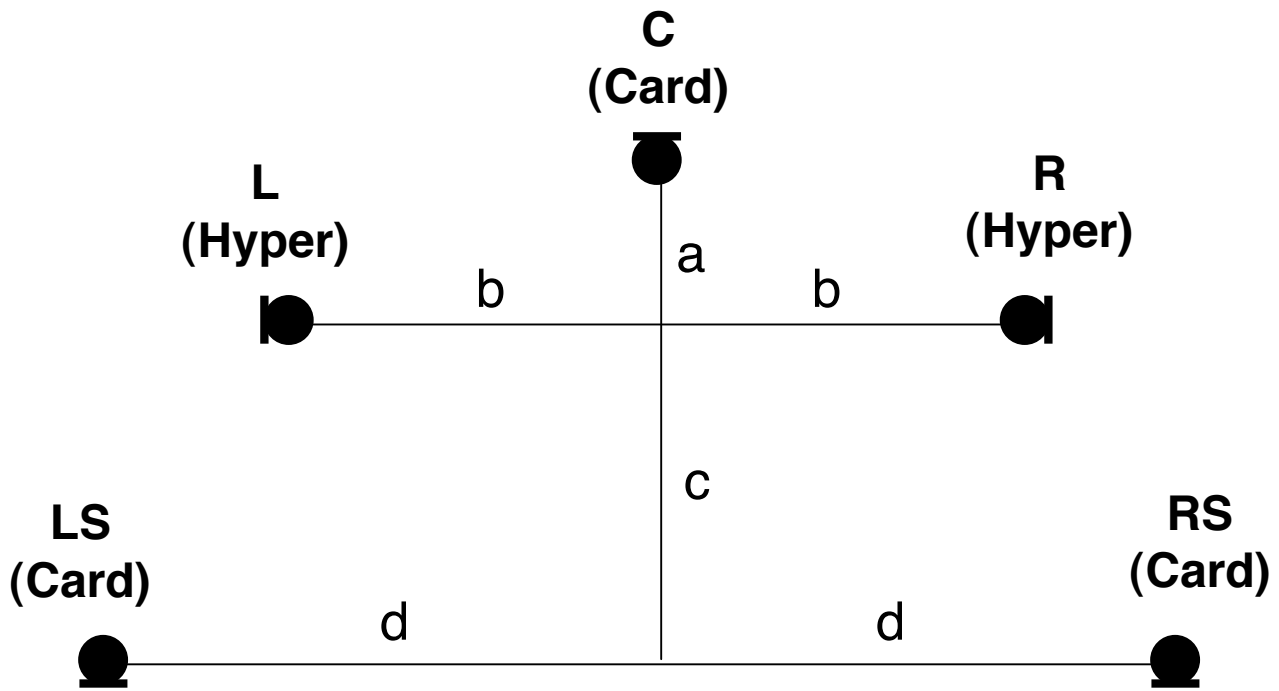
- Every recording situation requires a different microphone configuration
- Treat “standard” or “textbook” configurations only as suggestions
- Understand the behaviour of the microphones and their configuration but…
- Trust your ears!
- www.tonmeister.ca/research
- www.hauptmikrofon.de
- Michael Williams’s AES papers

Fukada Tree



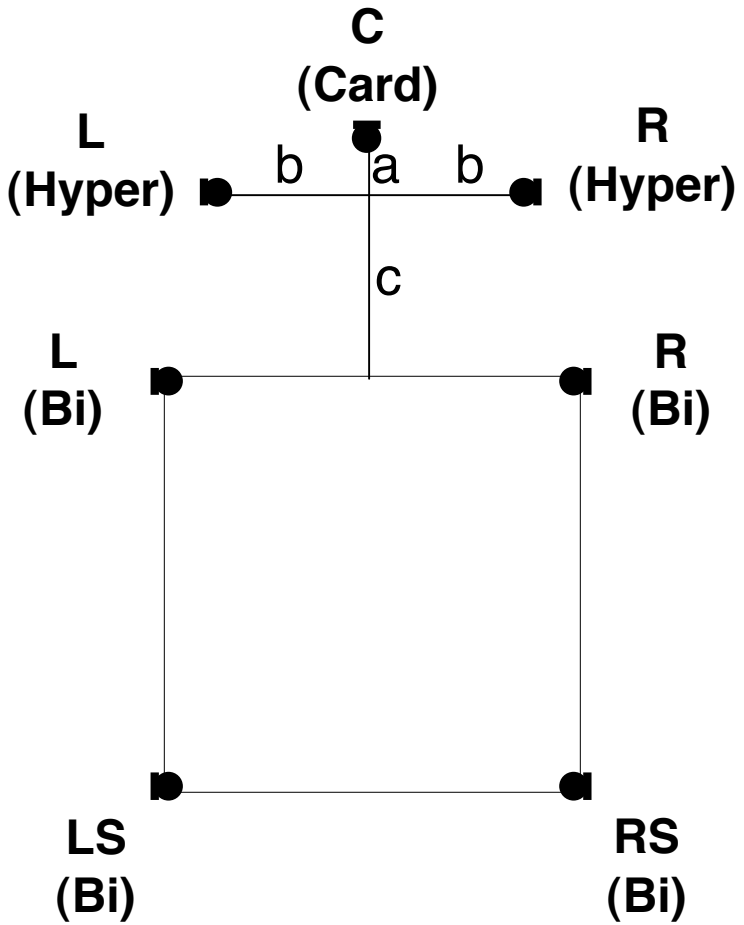
a=b=c = 1 - 1.5 m
d = 0 - 2 m
L / R angle = 110° - 130°
LS / RS angle = 60° - 90°

OCT Surround



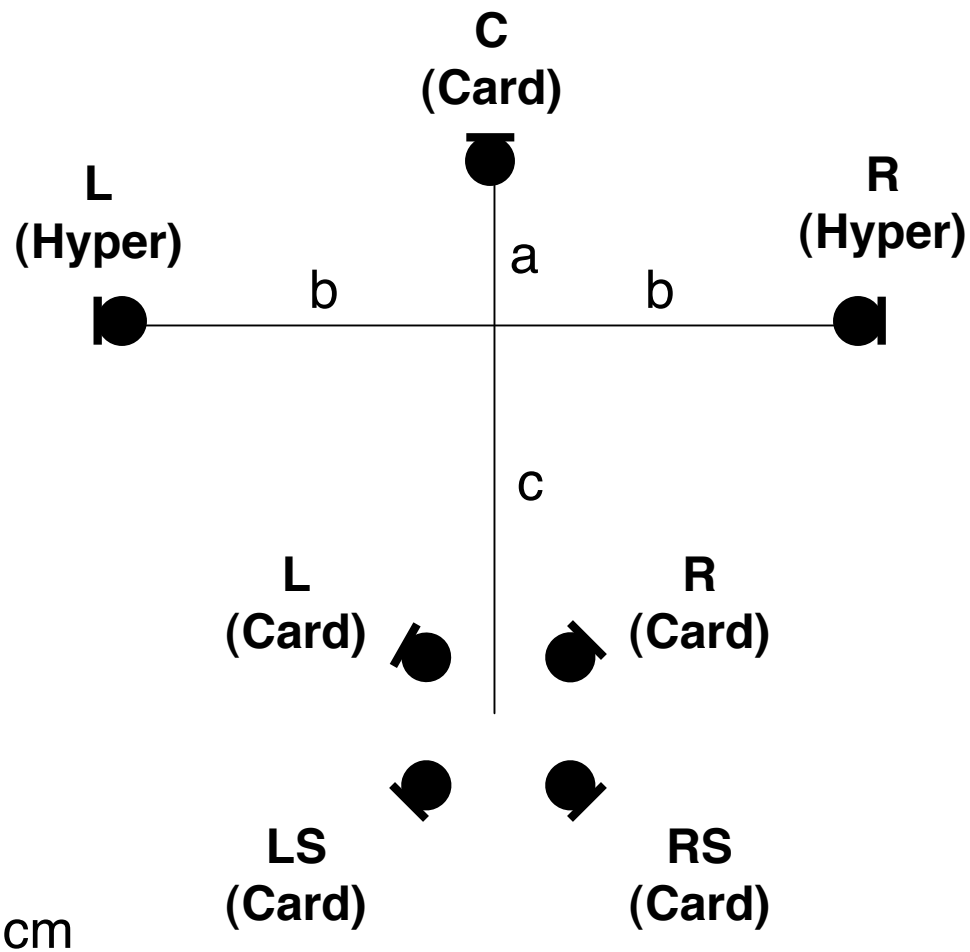
a = 8 cm
b = 40 - 90 cm
c = 40 cm
d = 10 - 100 cm

OCT Frontsystem + Hamasaki Square



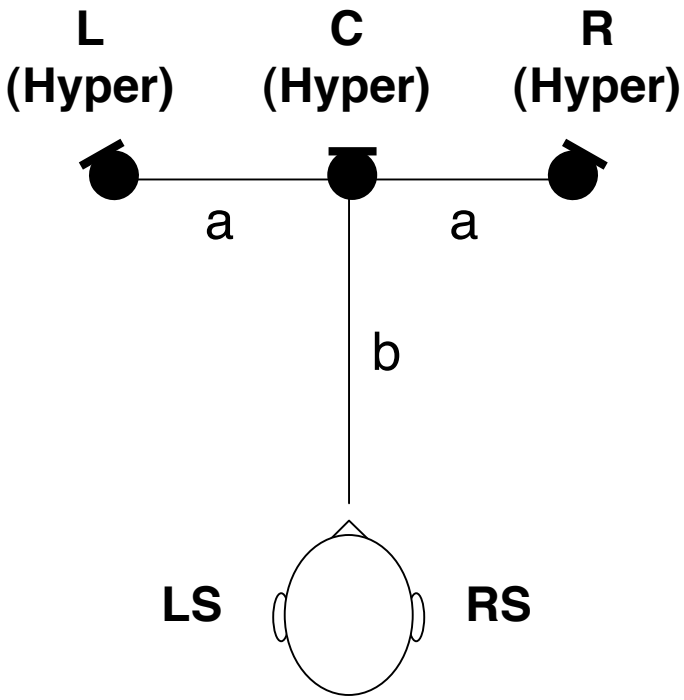
a = 8 cm
b = 40 - 90 cm
c = ~100 cm
Cross side = 2 - 3 m

OCT Frontsystem + IRT Cross



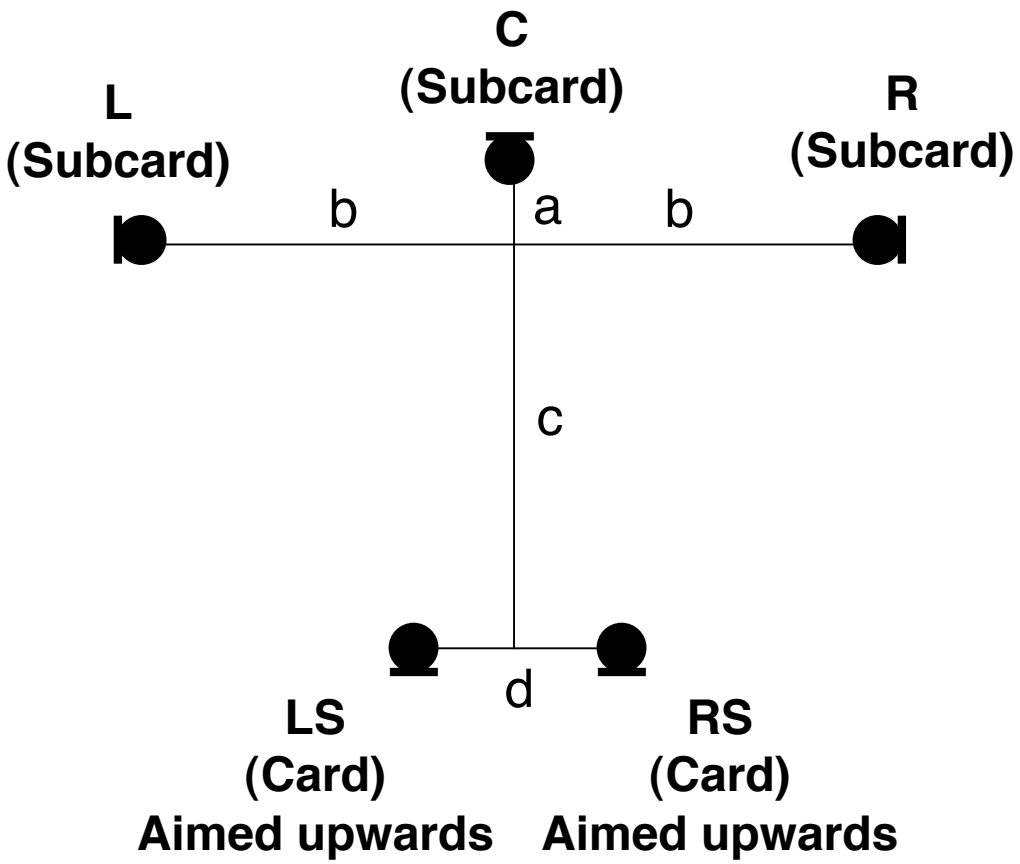
a = 8 cm
b = 40 - 90 cm
c = ~100 cm
Cross side = 20 - 25 cm

Klepko Technique



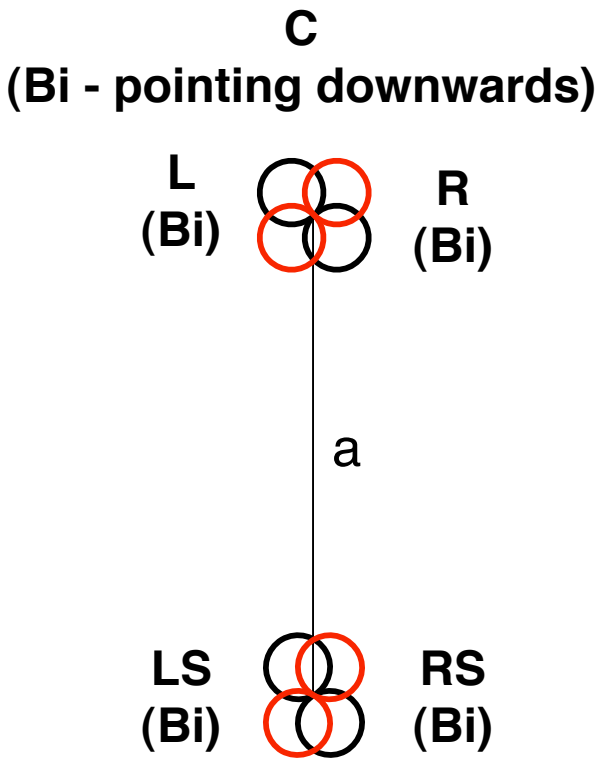
a = 17.5 cm
b = 125 cm
L/R Angle +/- 30°

Corey / Martin Tree



a = 0 - 15 cm
b = 60 - 80 cm
c = 60 - 90 cm
d = 30 cm

Martin Tree



a = < 70 cm
LS/RS angle = 45° - 90°