



SAURON

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Faculty Advisor: Prof. Tilman Wolf



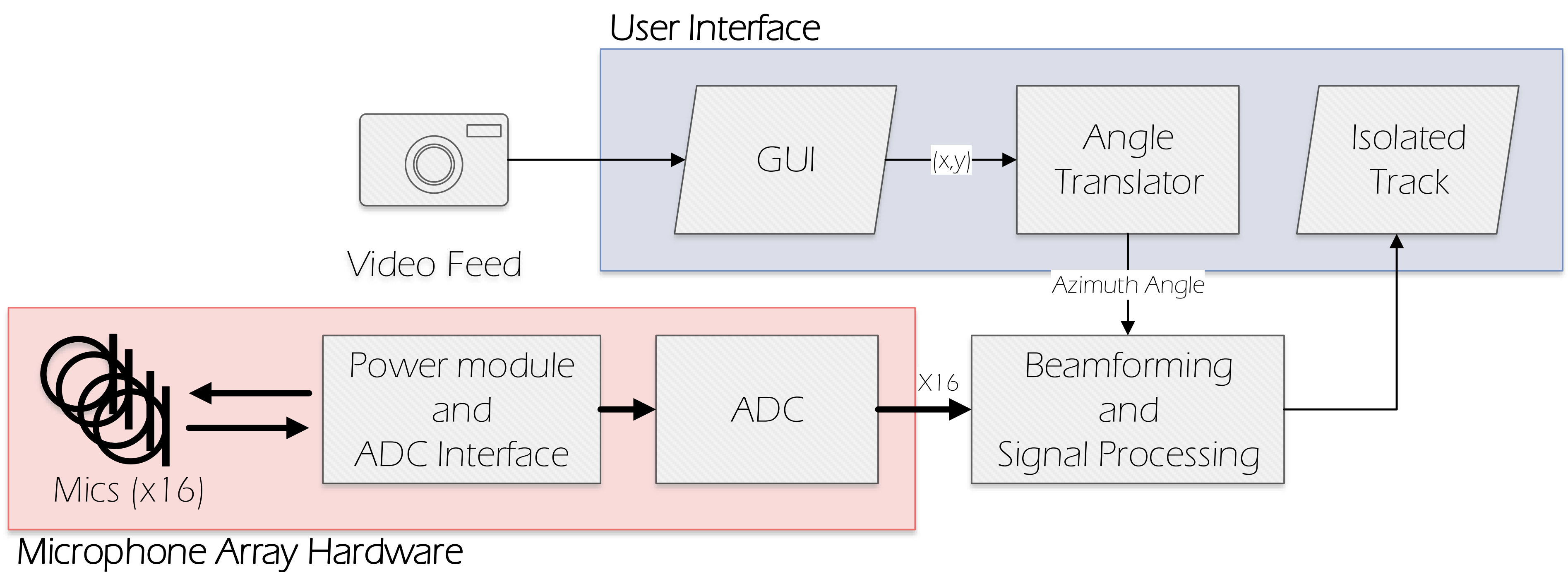
System Overview

Sauron is a successful demonstration of a security system that allows the operator to isolate audio in a selected location from a noisy environment.

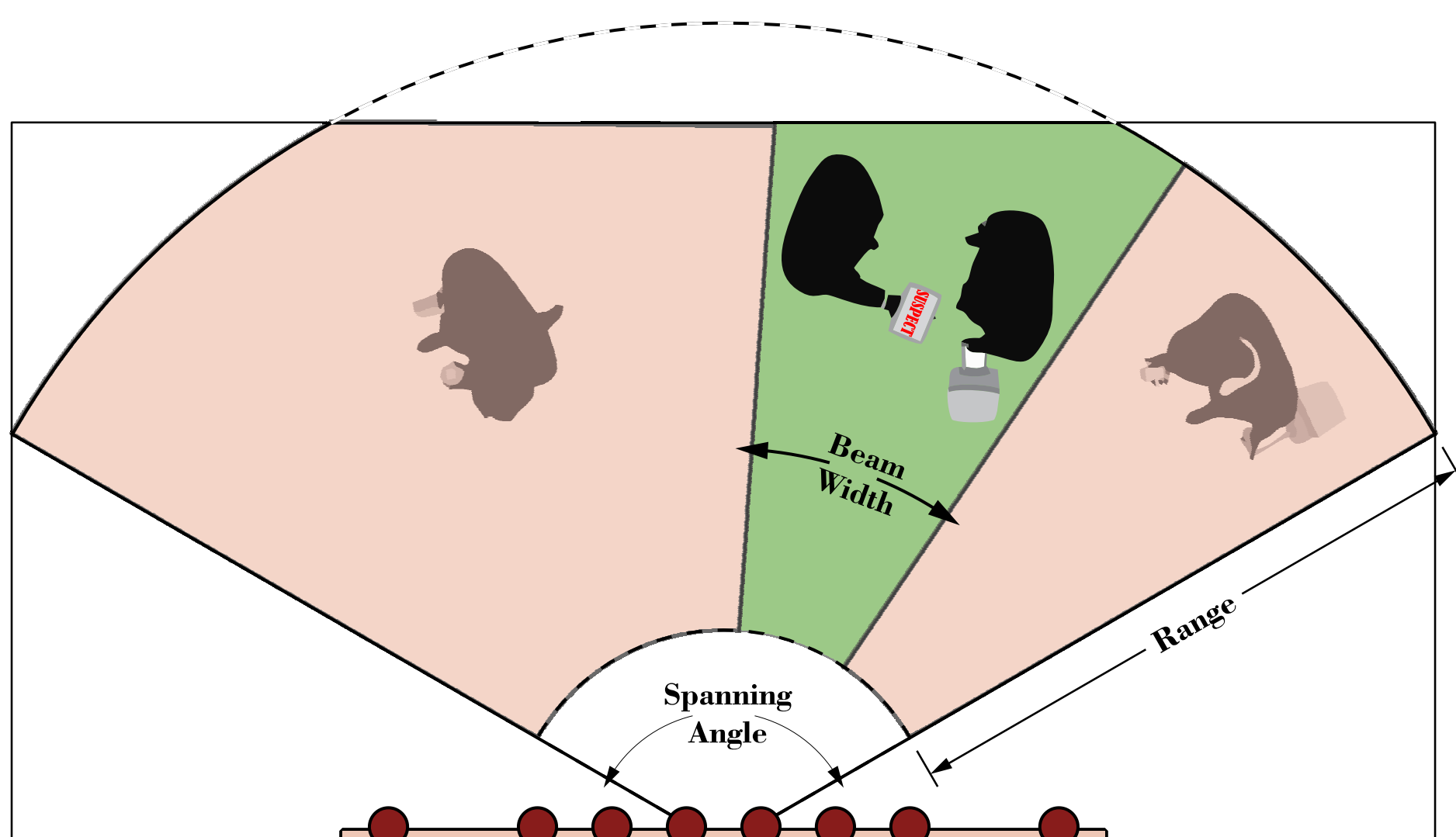
The user friendly GUI allows the operator to select an area of interest, which steers the beamforming algorithm. The algorithm relies on the inputs from a 16-channel microphone array to create a highly directional audio output.



System Block Diagram



Specifications & Results



All proposed specifications were met or exceeded.

SPECIFICATION	PROMISED	ACHIEVED
RANGE	1 TO 3 METERS	1 TO 3 METERS
ANGLE OF OPERATION	-65° TO 65°	-65° TO 65°
MAXIMUM -10DB BEAMWIDTH	40°	30°
FREQUENCY RANGE	1KHZ TO 3.5KHZ	500HZ TO 5KHZ
REAL-TIME DELAY	10s	5s
ERROR IN ANGLE SELECTION	20°	10°

Acknowledgements

Professor Wolf – our patient and loving advisor
 Professor Hollot – evaluation & feedback
 Professor Moritz – evaluation & feedback
 Francis Caron – purchases & storage needs

Professor Kelly – discussion of beamforming techniques
 John Shattuck – discussion regarding his SDP14 project
 Derek Clougherty – assistance with array construction
 ECE Department – additional funding

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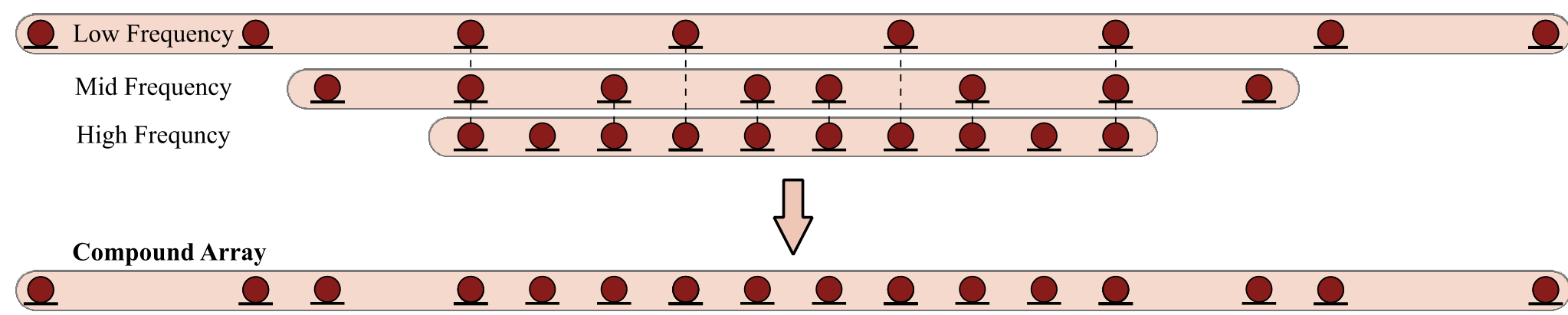
Department of Electrical and Computer Engineering
ECE 415/ECE 416
SENIOR DESIGN PROJECT 2016
 College of Engineering - University of Massachusetts Amherst



Microphone Array

Geometry

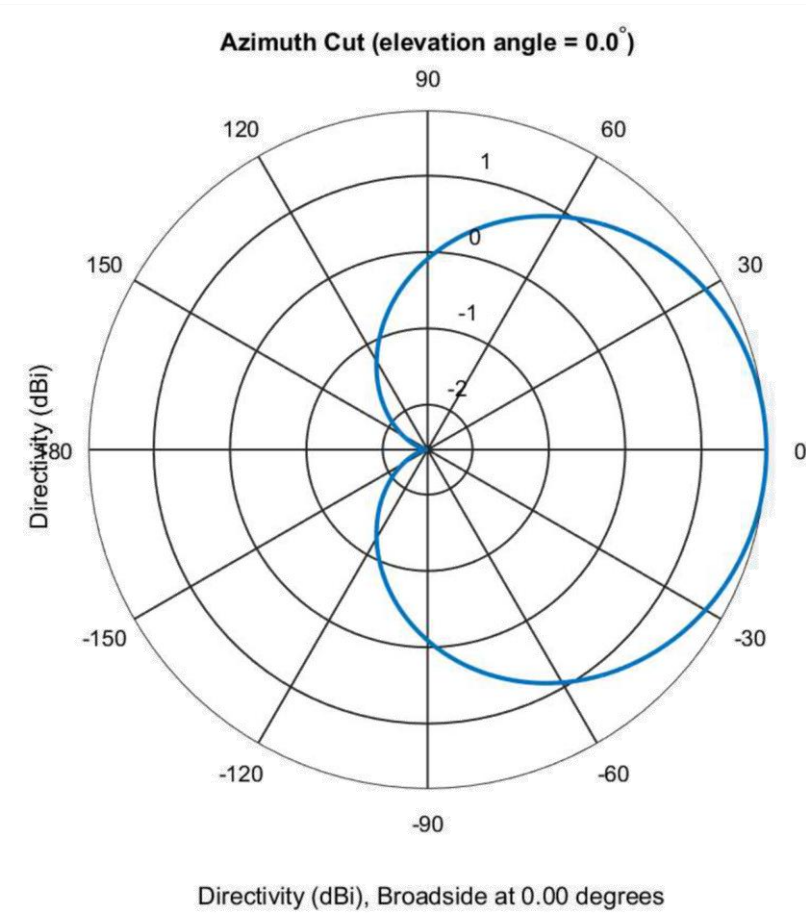
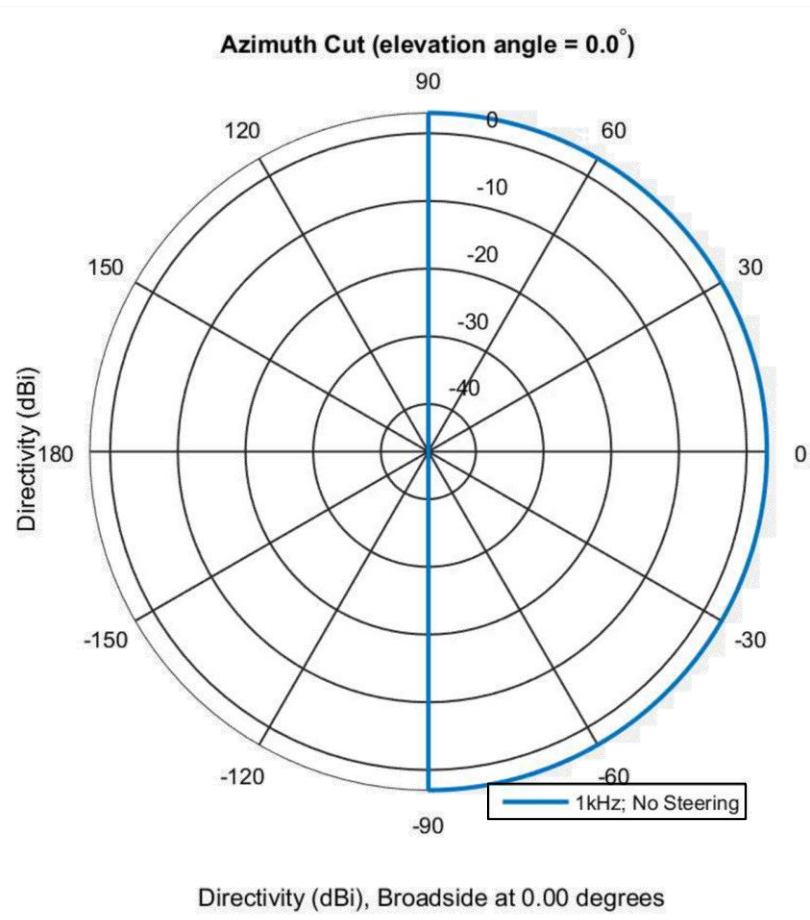
- ❑ 16 Microelectromechanical (MEMS) Microphones
- ❑ Compound array - Three superimposed linear arrays to provide consistent broadband beamforming
- ❑ Designed to cover human voice spectrum
- ❑ Optimized for high frequency which emphasize consonants to improve speech intelligibility



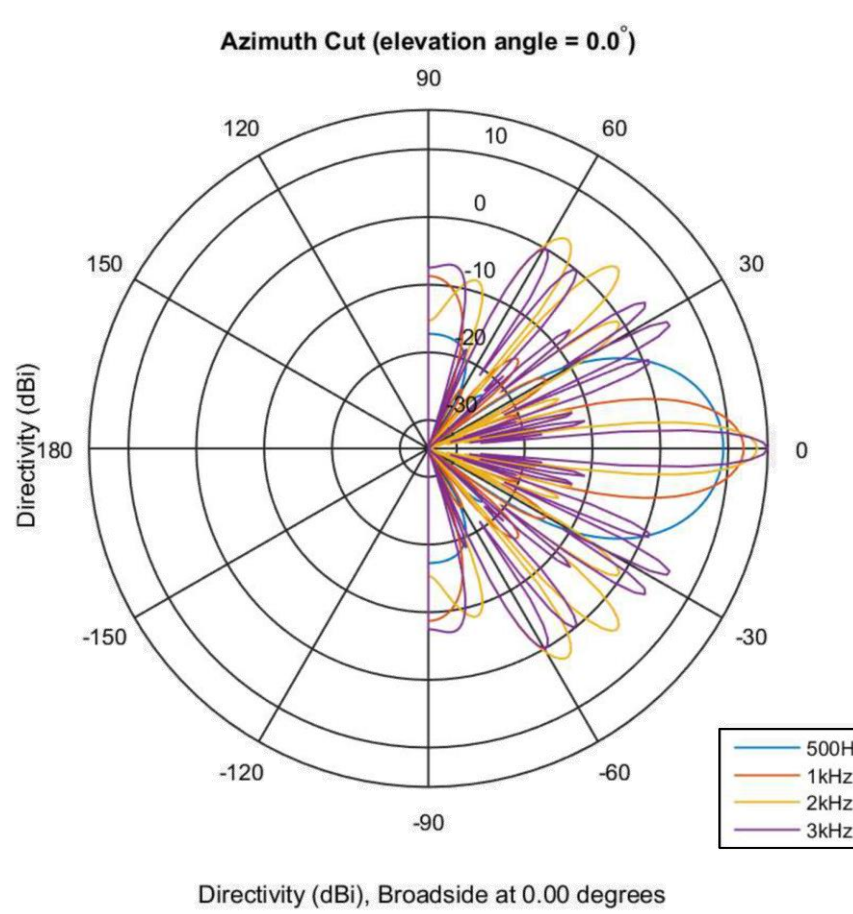
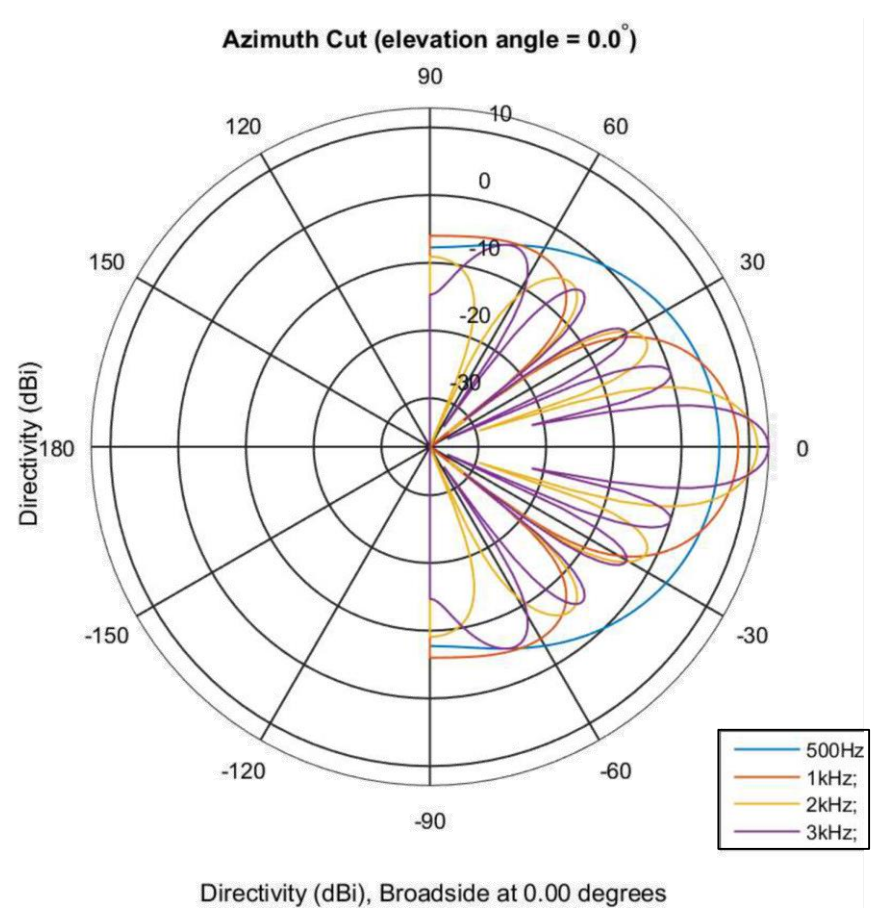
SubArray	Range (kHz)	Spacing (cm)	Microphones
Low	0.4 – 1	21	8
Middle	1 – 1.7	14	8
High	1.7 – 5	7	10

Polar Patterns

Omnidirectional (left) vs. Cardioid (right)



8 Microphone (left) vs. 16 Microphone (right)



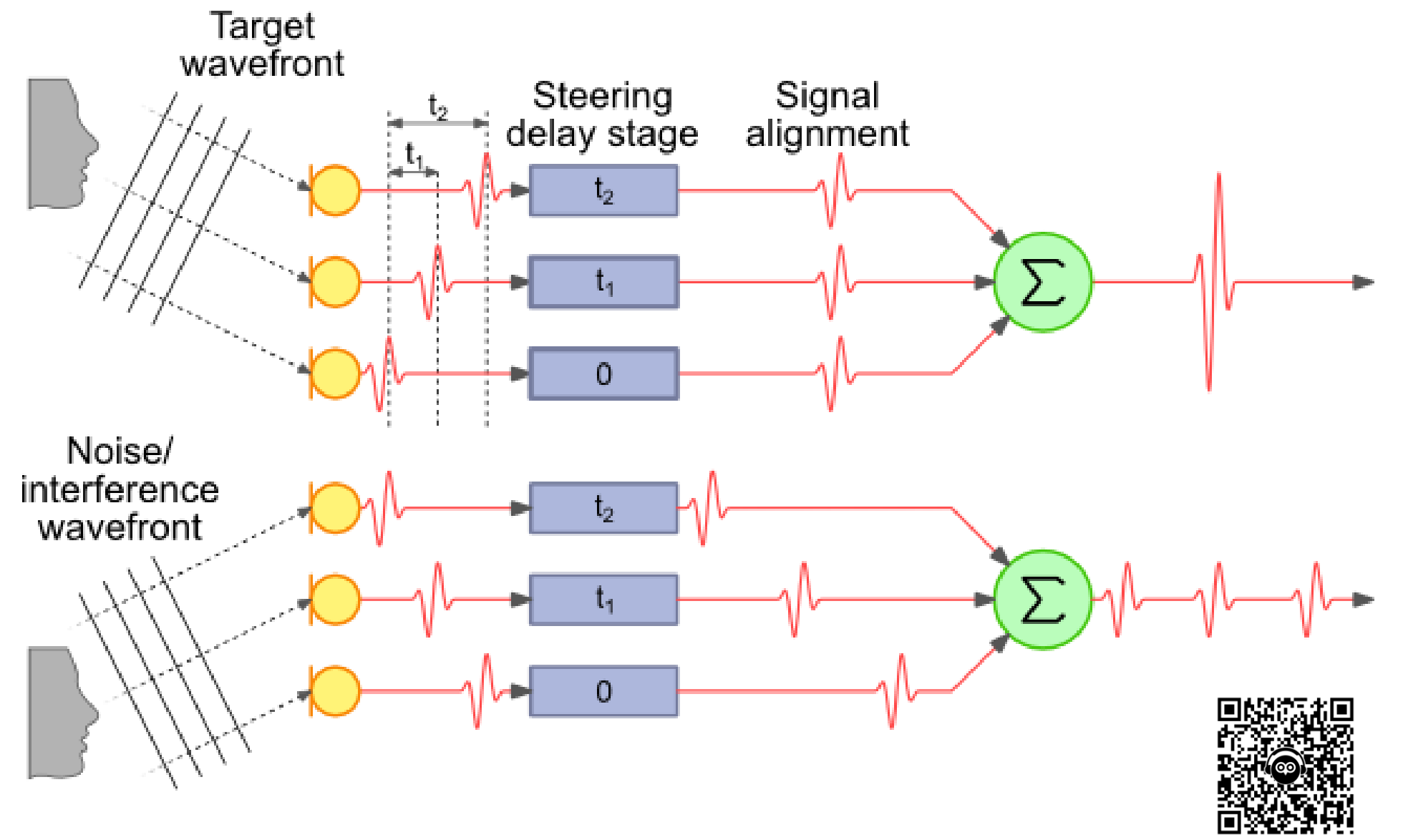
8 Microphones

Frequency	500 Hz	1 kHz	2 kHz	3 kHz
Directivity (dB)	5.6	8.4	11.2	12.87
Beam Width (deg)	90	50	30	20

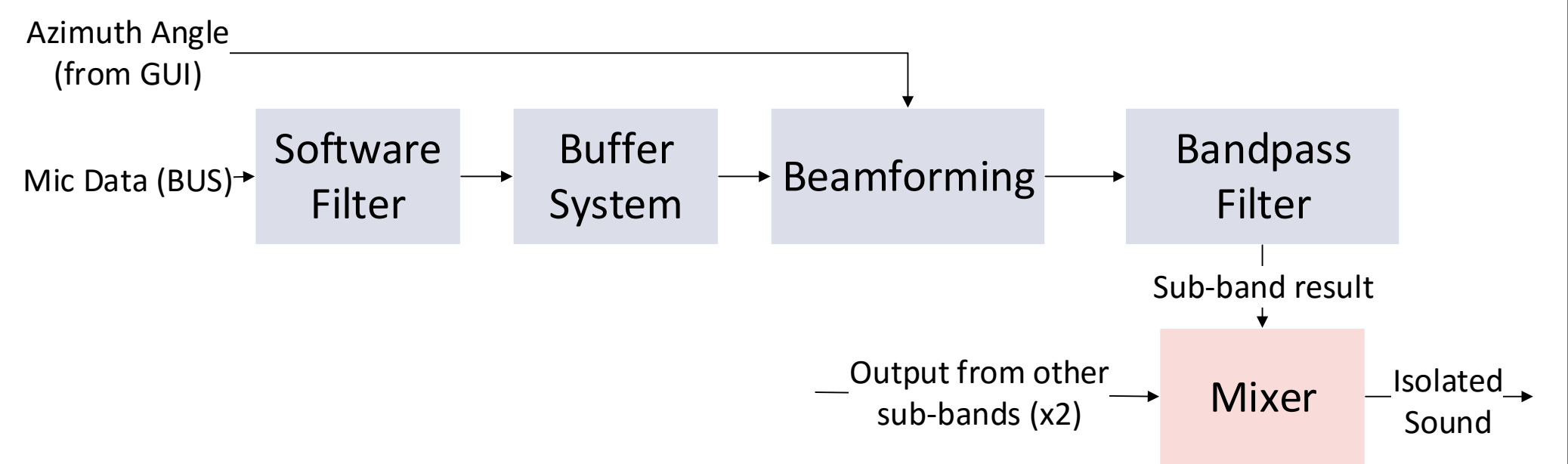
16 Microphones

Frequency	500 Hz	1 kHz	2 kHz	3 kHz
Directivity (dB)	8.4	11.28	14.19	15.9
Beam Width (deg)	30	20	15	10

Beamforming



- ❑ Operator selects a desired location
- ❑ Microphones pickup audio with different delays based on microphone's spatial location
- ❑ Audio tracks realigned and filtered in software to constructively interfere with desired signal
- ❑ Tracks are superimposed, amplifying only the sound propagating from the desired direction
- ❑ Gain is directly related to number of microphones



Graphical User Interface



- ❑ Video input provides visual of operating site
- ❑ Visual coordinates converted to steering angle
- ❑ Provides visual indicator of beam direction

Cost

Component	Price (\$)	UOM	Qty	Production Cost (\$)	Development Cost (\$)
MATLAB	Free for UMass	item	1	N/A	0
Microphone Module	10.00	item	16	160.00	160.00
Microphone Mount	1.50	item	16	24.00	24.00
Alpha Wires	0.50	feet	6	3.00	3.00
NI ADC	650.00	item	1	650.00	650.00
MicroUSB Breakout	2.00	item	1	2.00	2.00
3.3V Regulator	2.00	item	1	2.00	2.00
1 μF Capacitors	0.25	item	2	0.50	0.50
FR-4 Board	Free Samples	ft ²		20.00	N/A
Camera	45.00	item	1	45.00	45.00
TOTAL				906.50	886.50