# Microphone Beamforming

## Syntronic Presentation For Chalmers DAT096

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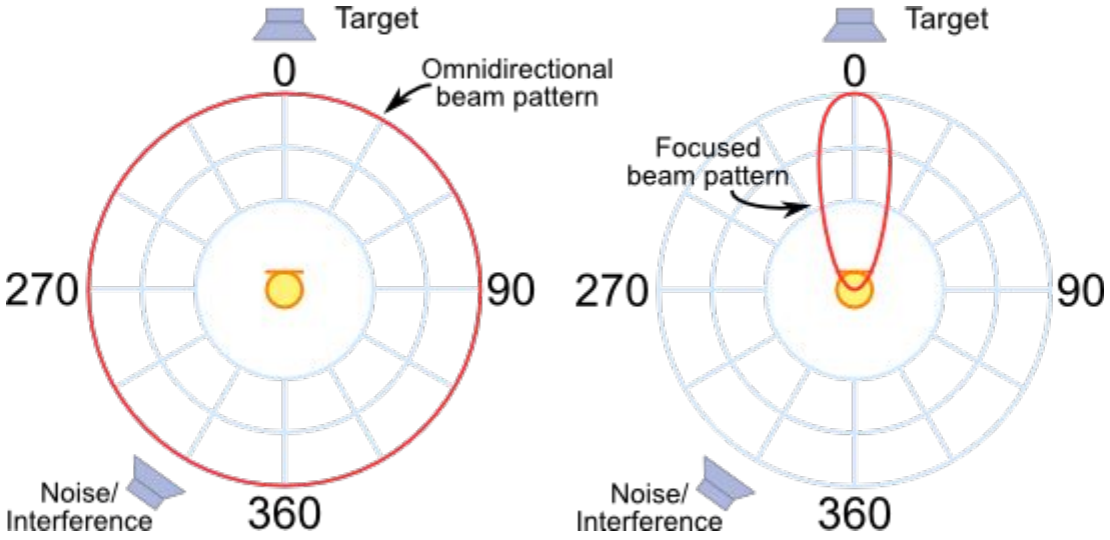
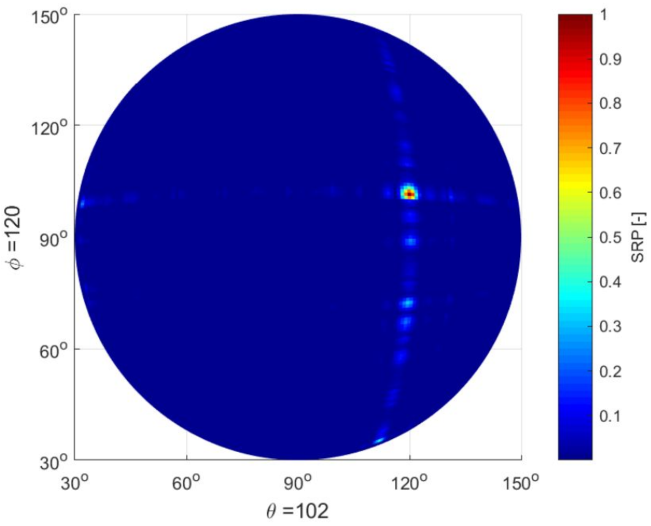
# What is beamforming ?

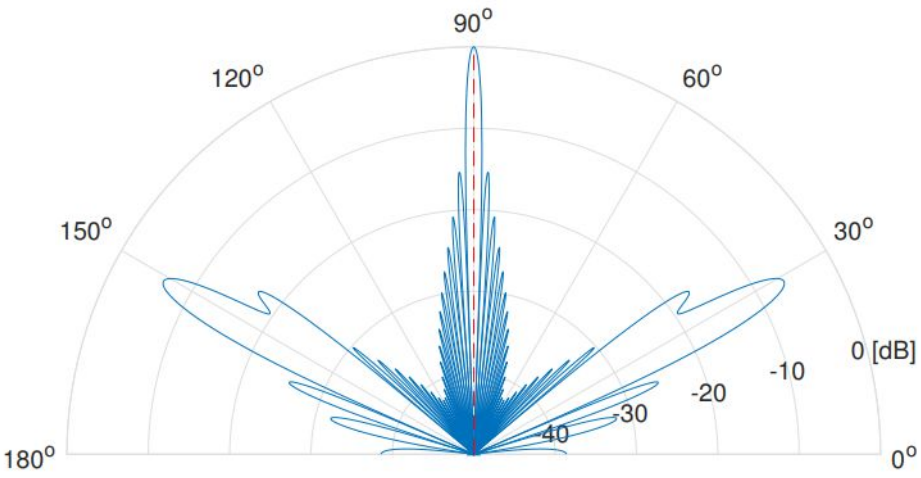
-Sampling information in time and space and applying signal transformations in order to achieve spatial filtering.



# Applications

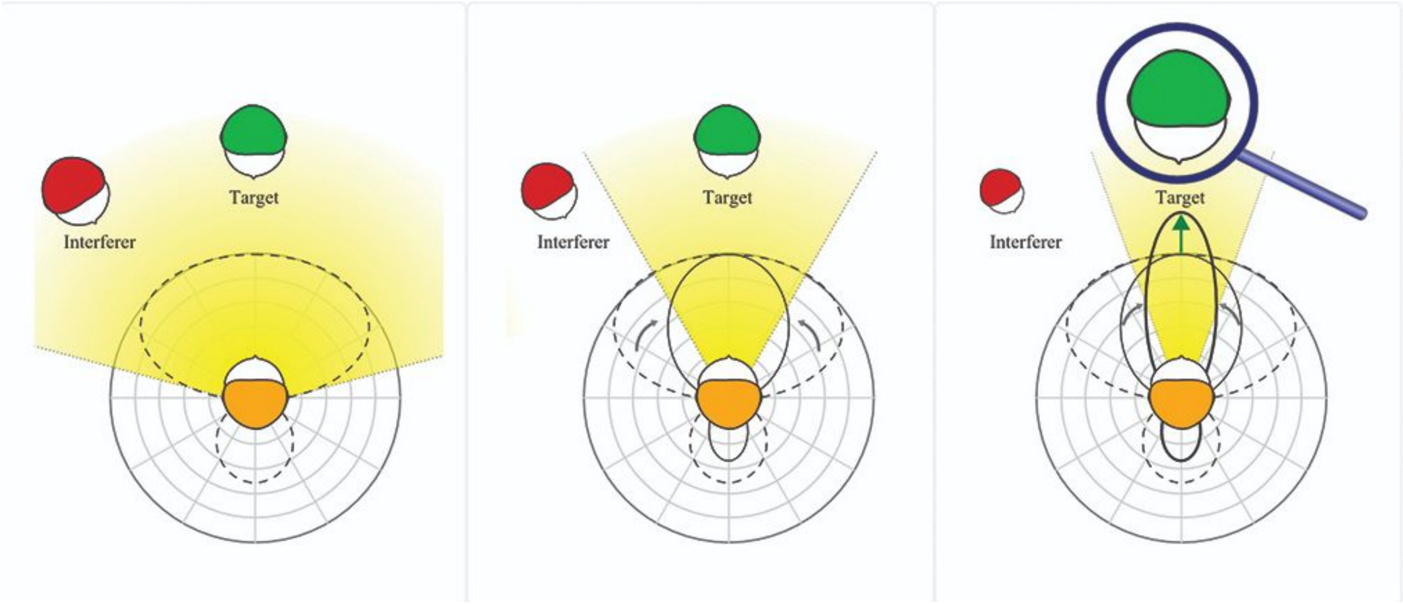
-Source sound localization (Direction of Arrival)



# Applications

-Directional Speech enhancement

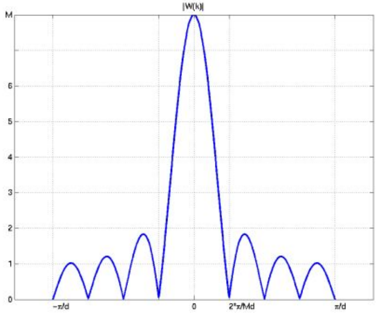


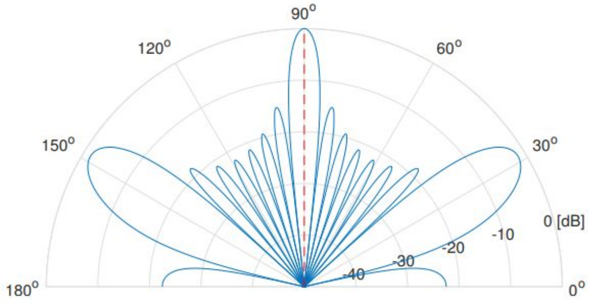
# Nuances of spatial sampling

-Spatial sampling theorem similar to nyquist applies to spatially sampled signals in order to prevent aliasing.

-Signals must be sampled in space with distance d < lambda/2

-More important for narrowband signals than wideband signals



# Arrays

-Represent how you sample signals “in space”. Can be in 1, 2 or 3 dimensions and consist of 2 or more sensors

-Shape of an array will affect how to solve for the directionality of the array.

-The set of delays which maximally add together the wavefront of an incoming wave at a certain angle is the current “viewing” direction of the array.

-Distance between microphones will dictate what frequencies the array can be optimized for.

# Beamforming Algorithms - Conventional

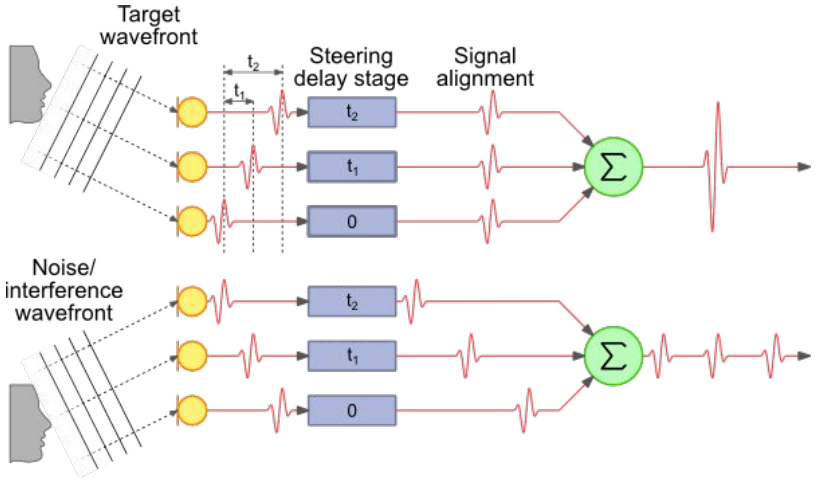
-Fixed weighing and processing of signals to produce spatial filtering effect.

Examples:

Delay and Sum

Filter and Sum

Frequency Domain Beamforming



# Beamforming Algorithms - Adaptive

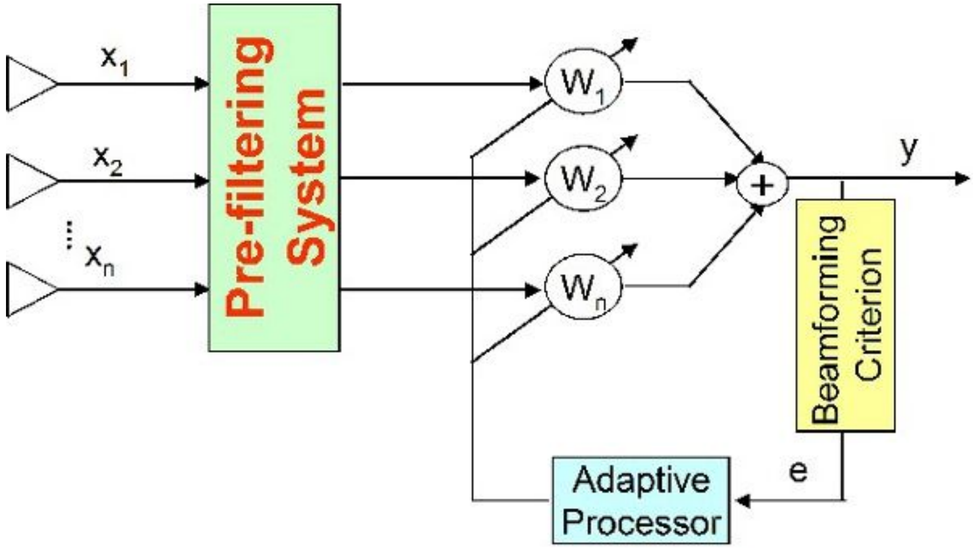
-Adaptively modify the delay and weights of the beam to achieve optimal result

-Adjust the beam to cancel interference in comparison to target, ie nulling.

-Generally more complex

Examples:

Least-Mean-Squares
Recursive-Mean-Square
Generalised SideLobe Canceler



# Algorithm differences between applications

-Speech enhancement and isolation involves more around selecting weights/delays to constructively and destructively add waveforms together to either enhance certain sources over others or separate sources.

-Localization involves more around scanning and searching. With focus on finding the beam orientation with maximum input signal power

Example Source-Localisation Algorithms:
SRP-PHAT

# Real time suitability of algorithms

- Not all algorithms are suitable for real time systems.
- Complex mathematics difficult to implement on FPGA
- Cross correlation algorithms grow exponentially with number of sensors in array (grid search localization).
- FPGAs have limited resources.

# System Dynamics

Designing the system is a tradeoff between requirements, performance and resource use.

-**Increasing sampling speed**

Causes Increased resource usage [Filter lengths]

Decides minimum difference in delay possible between two signals (beam resolution).

Allows higher system SNR with decimation and filtering

-**Increasing amount of sensors**

Causes increased resources usage [Amount of filters]

Allows narrower beams

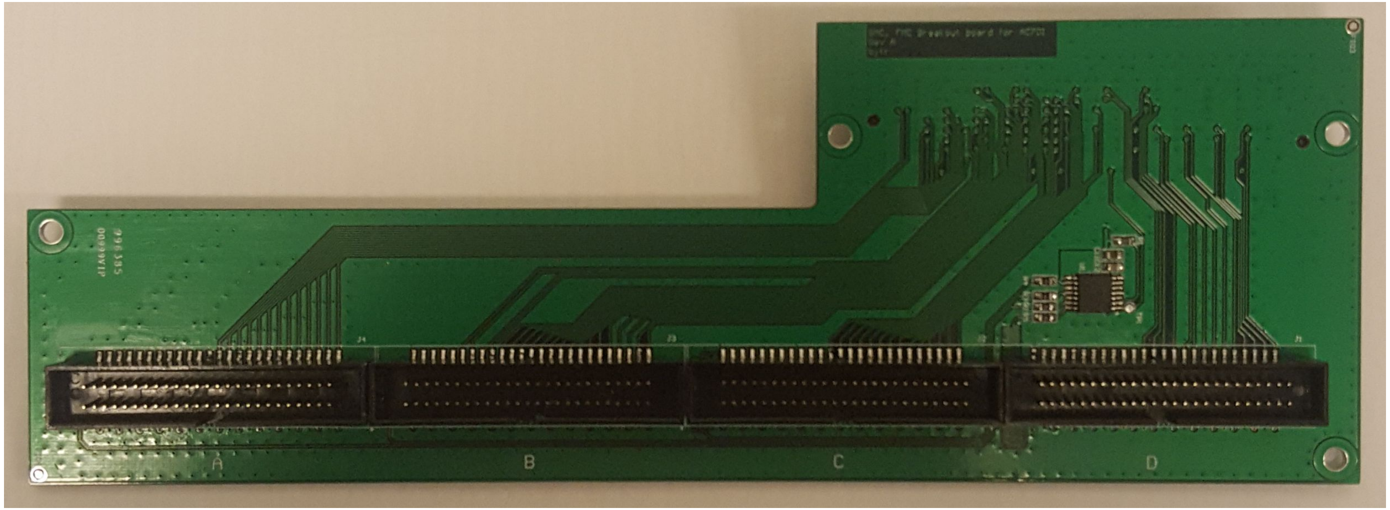
Allows higher system SNR

# Syntronic Hardware - FMC Breakout

-FMC Breakout board for AC701

-Support for up to 4 separate panels with 24 microphones each, or one with 96

-Breaks out FPGA signals on FMC connector and propagates clock to all MEMS microphones



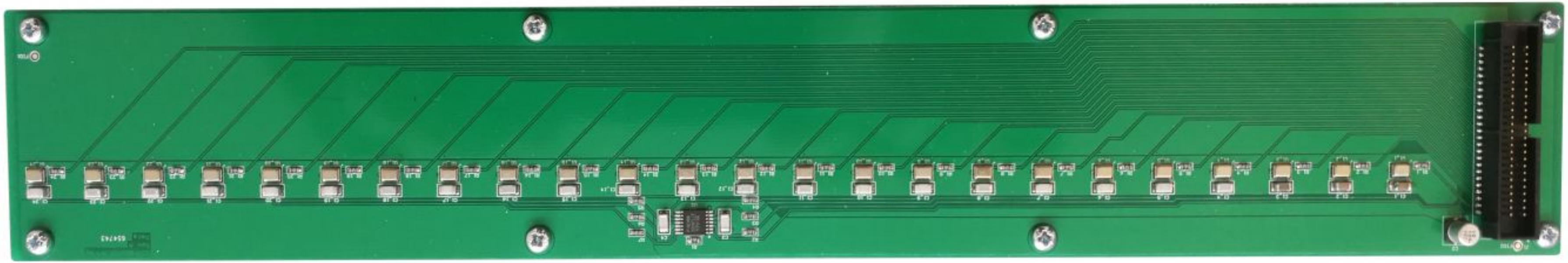
# Syntronic Hardware - Linear Arrays

-Linear array of 24 MEMS microphones.

-Good for testing and development, but may not be optimal for speech.

-D=11.43mm

-You can make your own! We have schematics and guidelines on how to best achieve this.

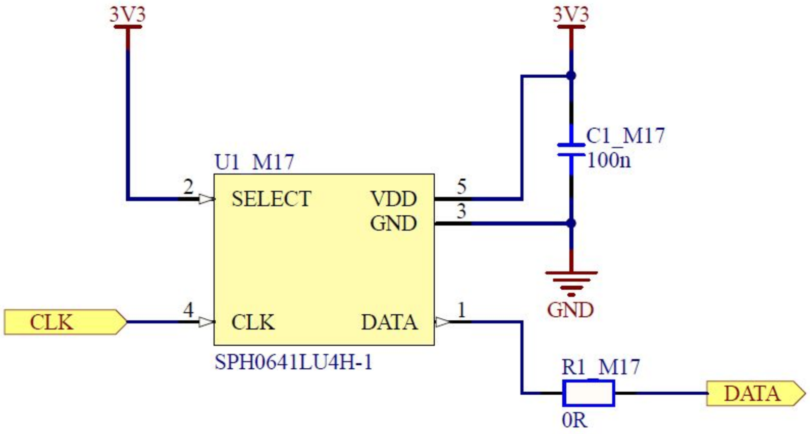


# Syntronic Hardware - Microphone

-The Syntronic Array uses an Ultrasonic microphone SPH0641LU4H-1.

-Can be clocked at different frequencies to get different bandwidth. 20Hz to ~80Khz @ 4.8Mhz

-Oversampled output in PDM format,
Needs to be filtered to get PCM format




Microphone Channel

# Thank you for having us!

Questions ?

SYNTRONIC