



A time reversal metasurface for mimicking the cocktail party effect

Constant BOURDELOUX

Ph.D. advisers : Mathias FINK and Fabrice LEMOULT

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THE COCKTAIL PARTY EFFECT

The cocktail party effect is the capability to focus one's auditory attention on particular audio sources while ignoring other audio sources.

THE COCKTAIL PARTY EFFECT

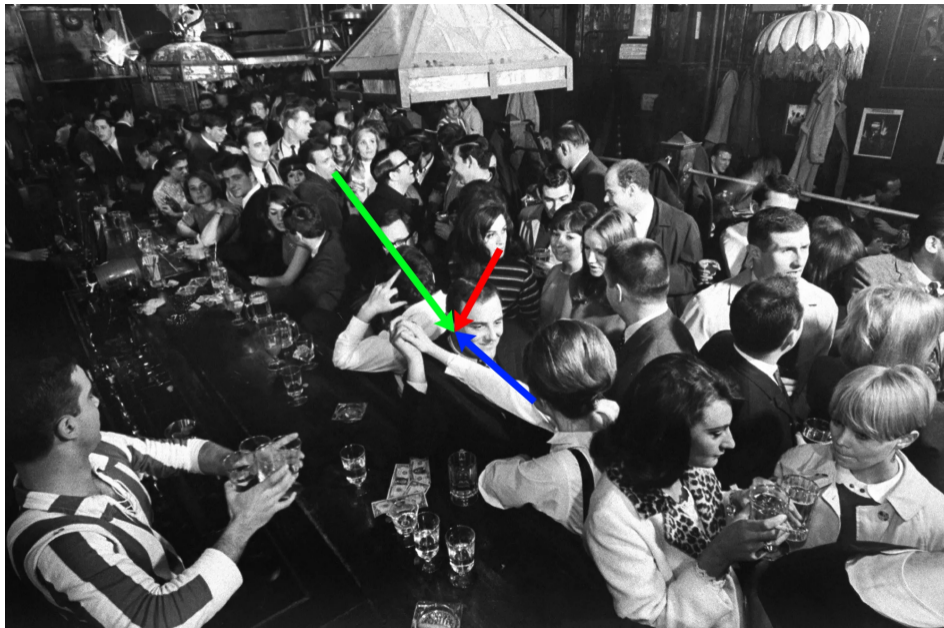


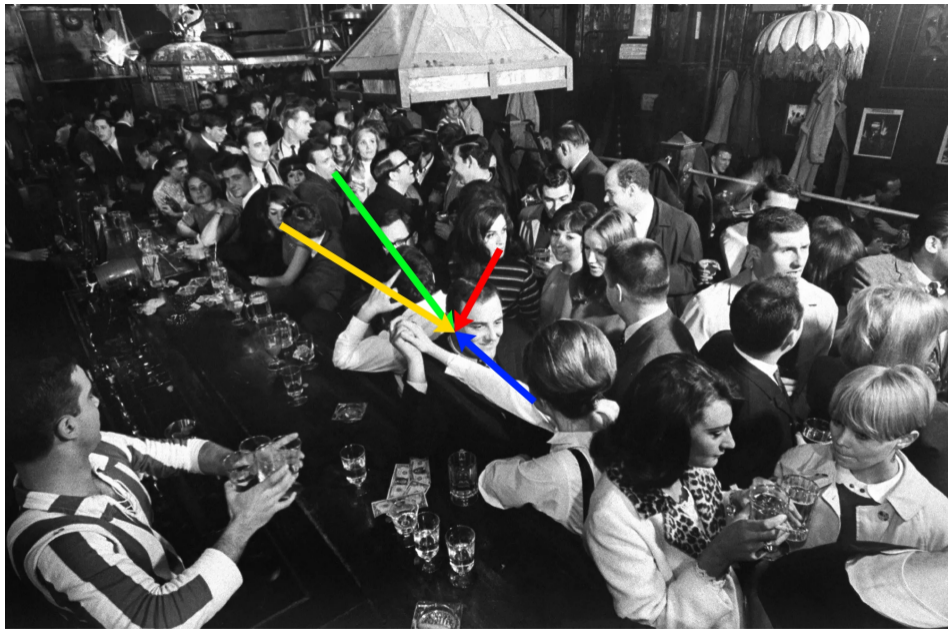
TGI Fridays, New York City, 1965 – photograph by Ralph Morse







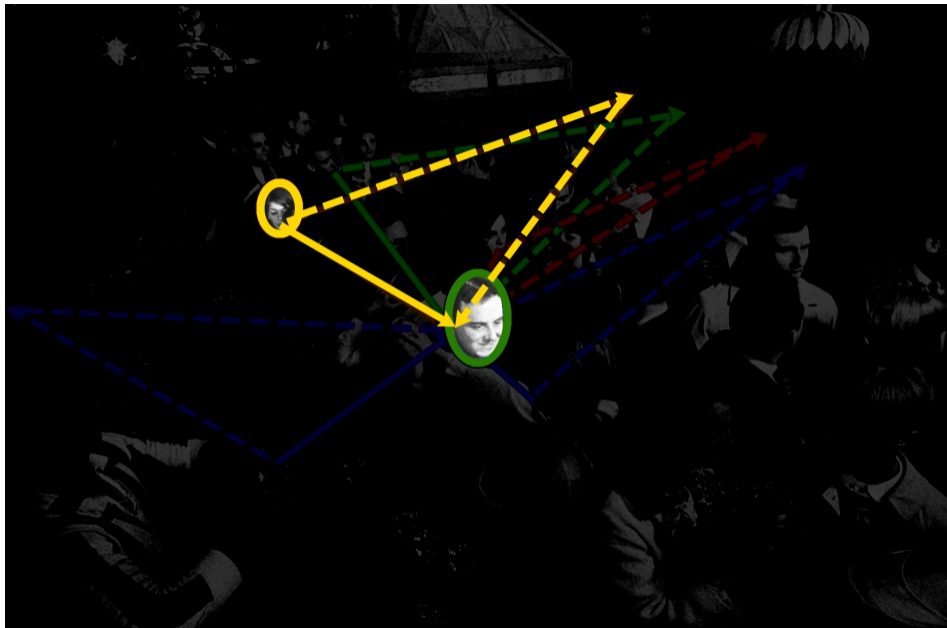


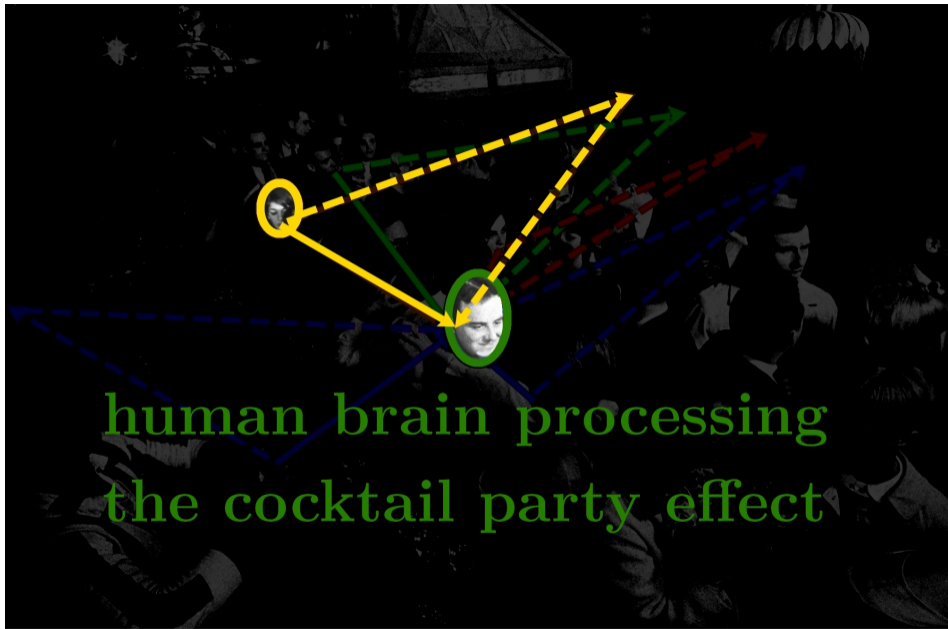








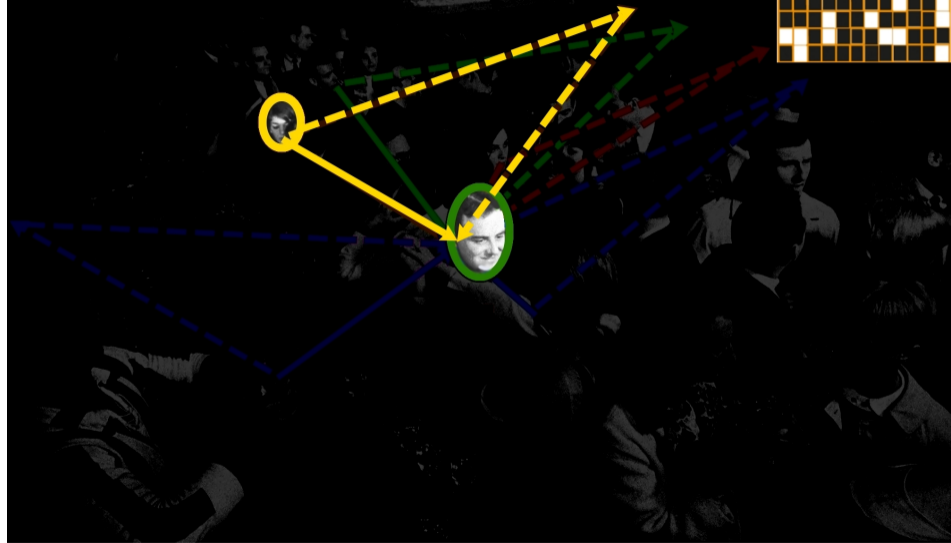
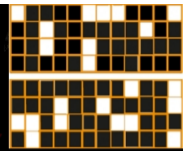




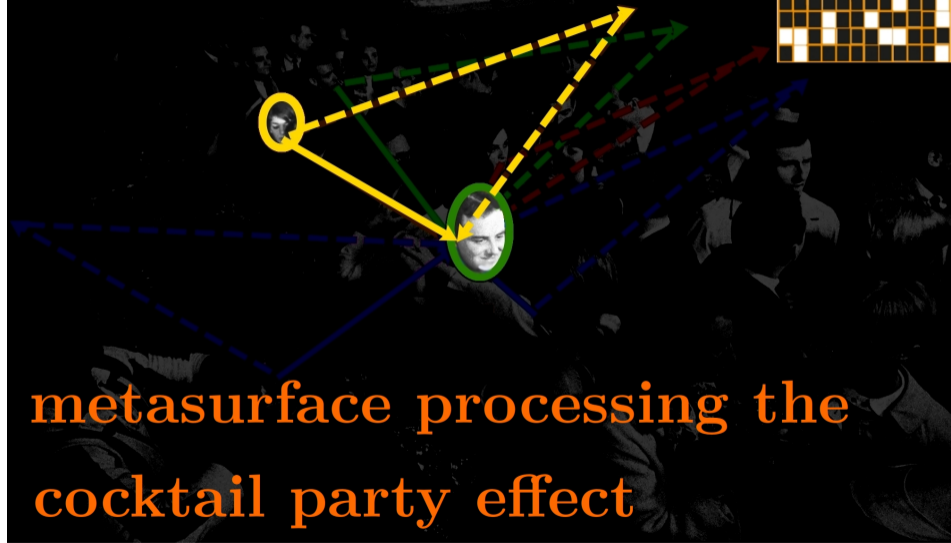
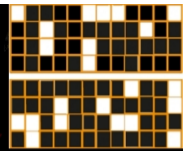
human brain processing
the cocktail party effect



metasurface ON

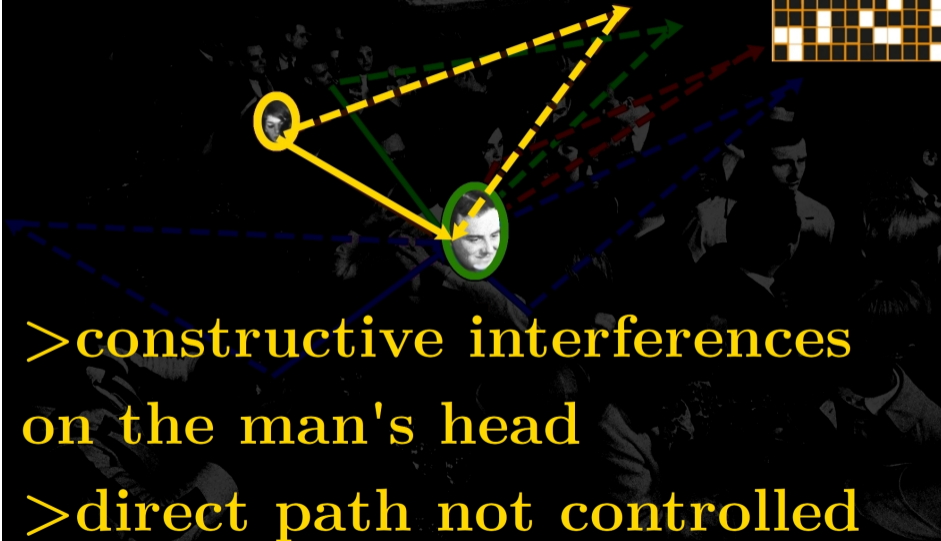
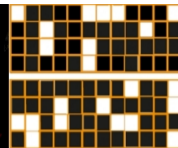


metasurface ON

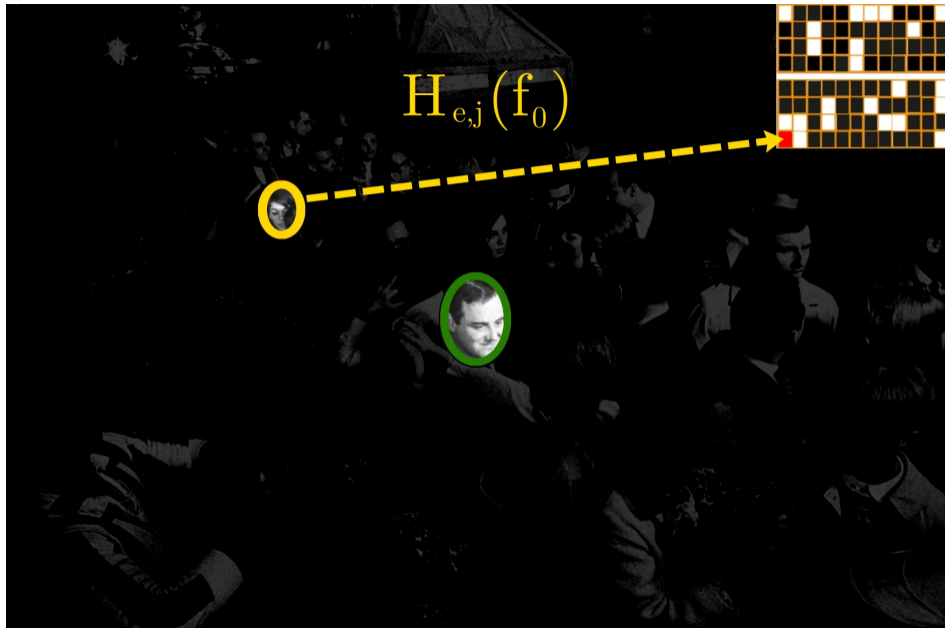


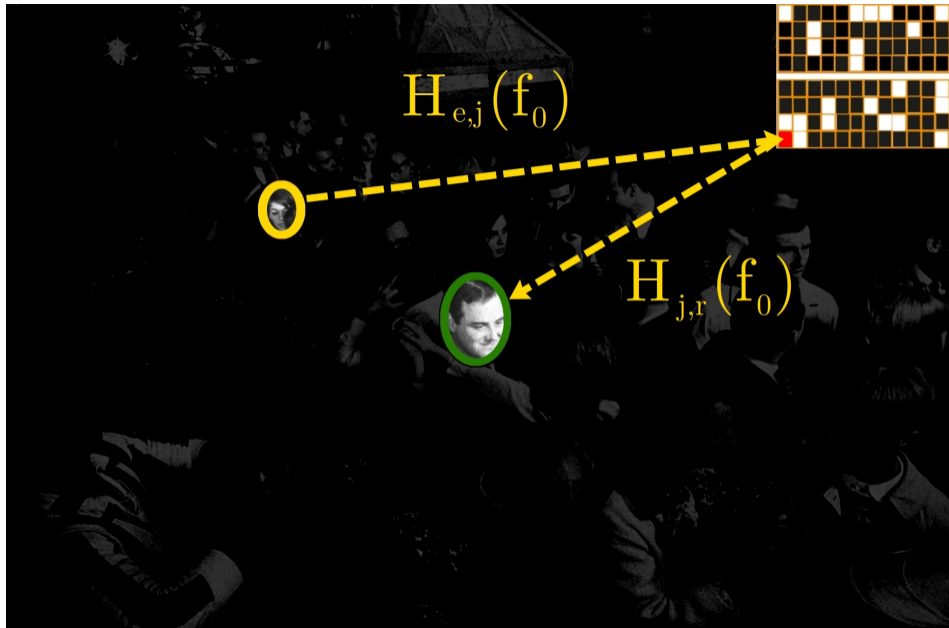
metasurface processing the cocktail party effect

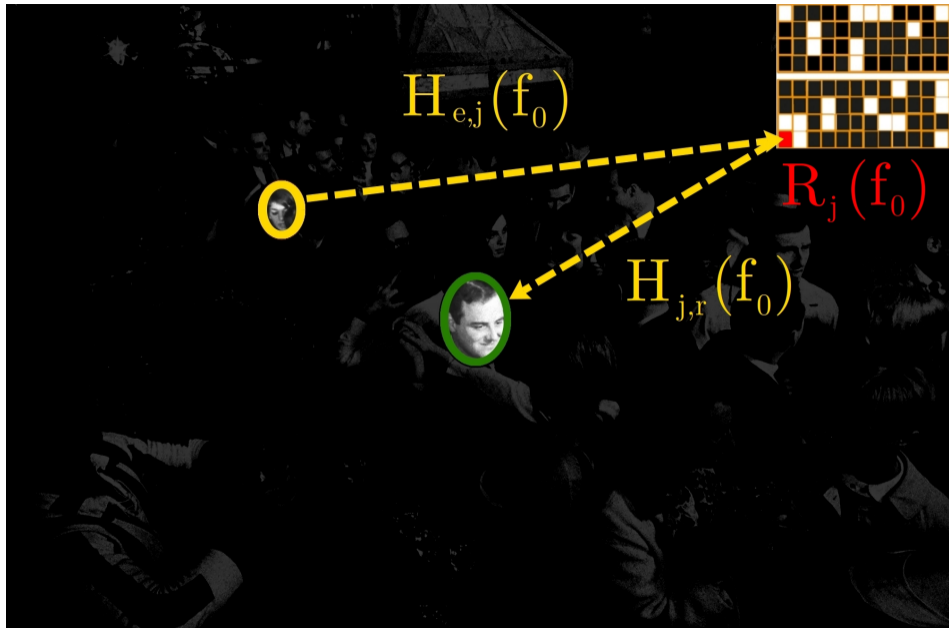
metasurface ON

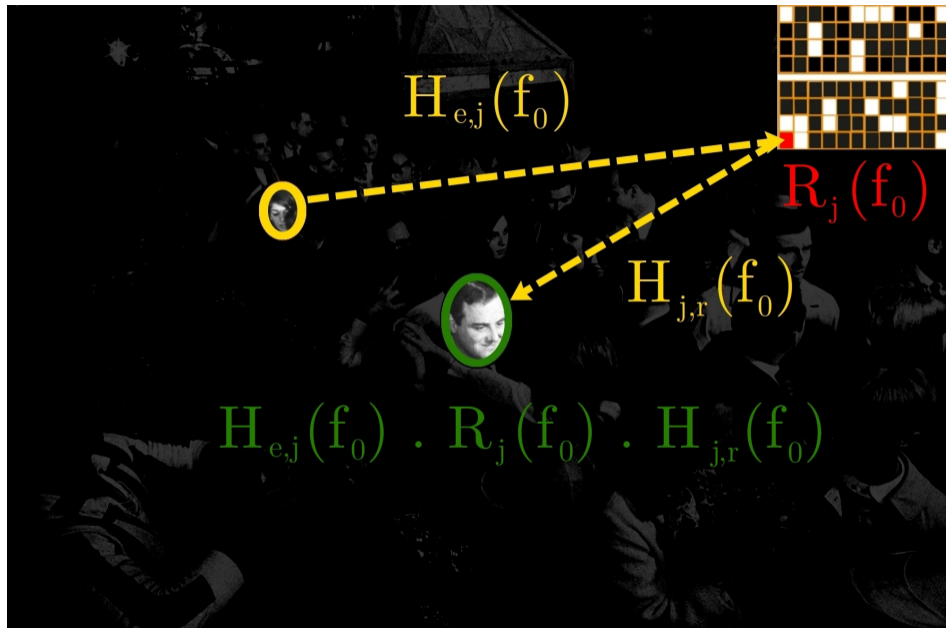


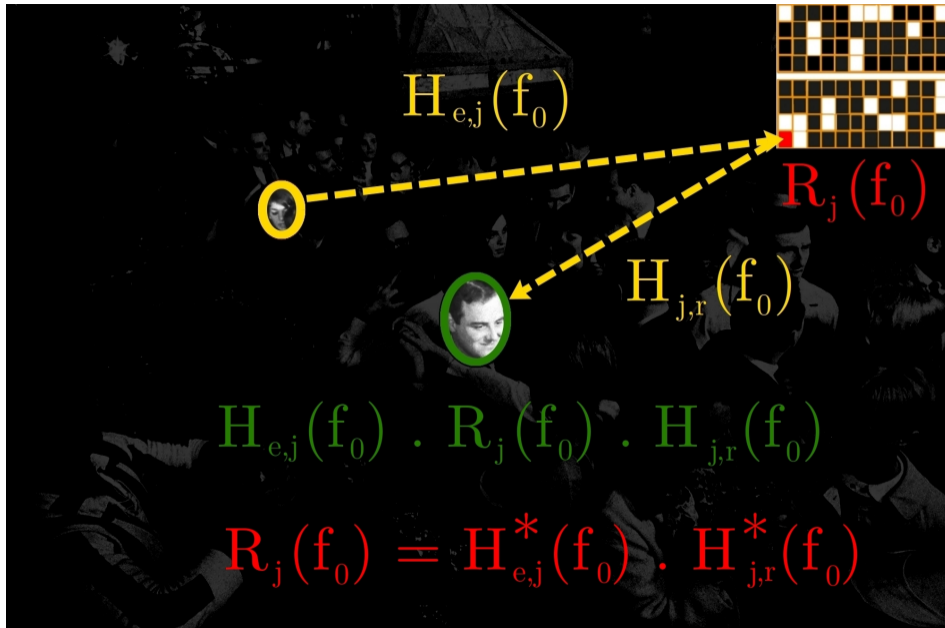
>constructive interferences
on the man's head
>direct path not controlled





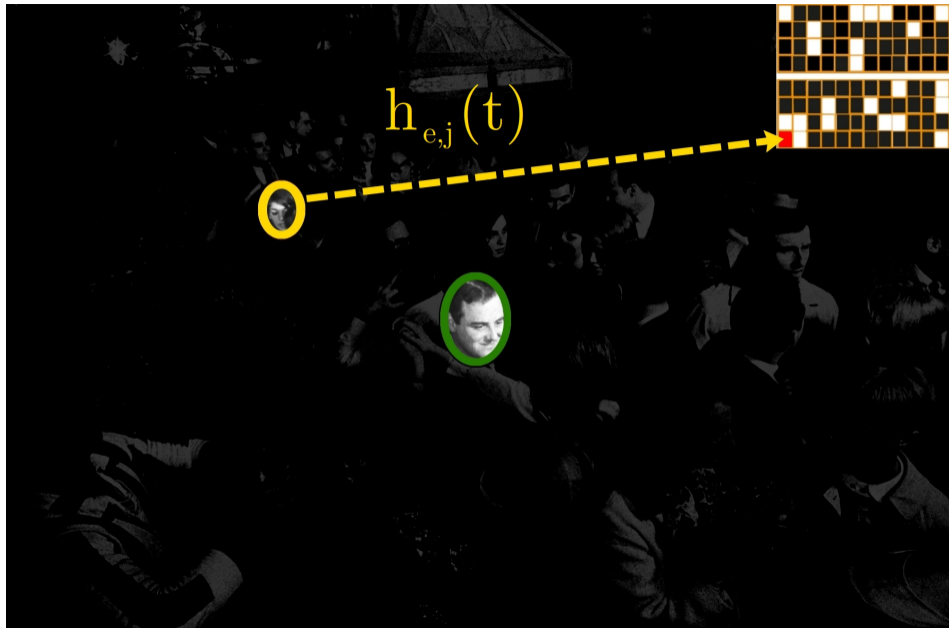


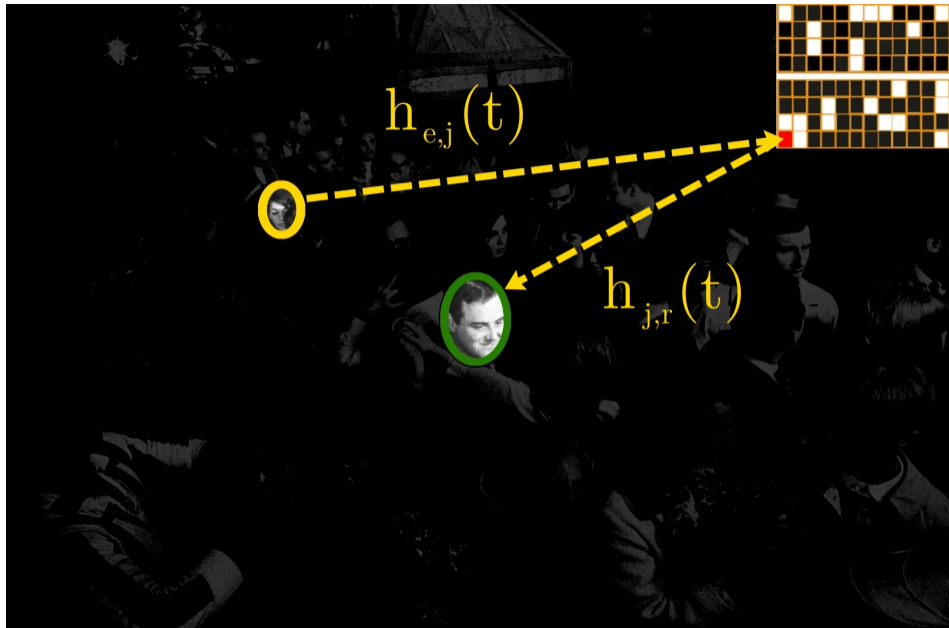


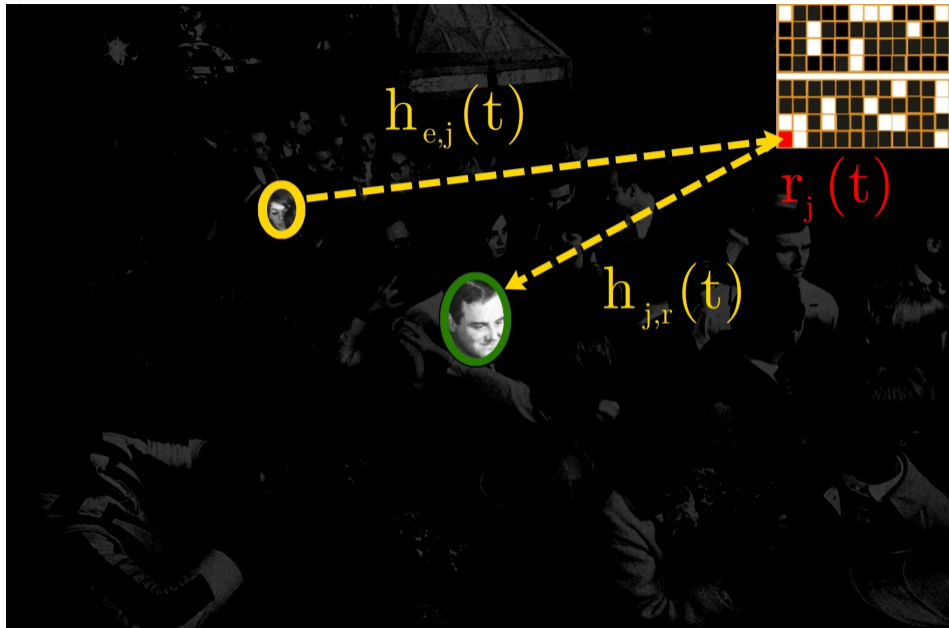


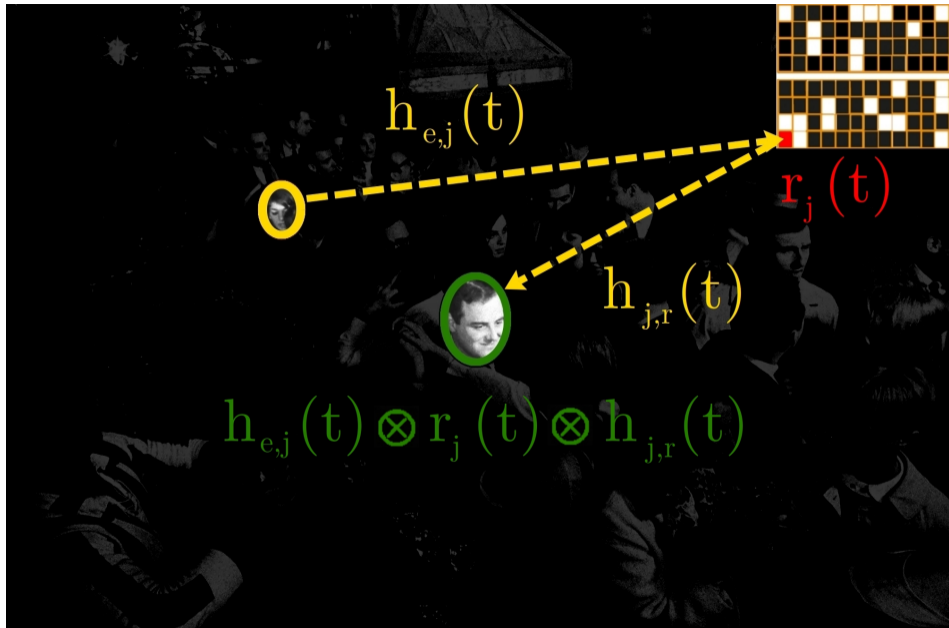
It's nice focusing waves in a monochromatic regime at f_0 .

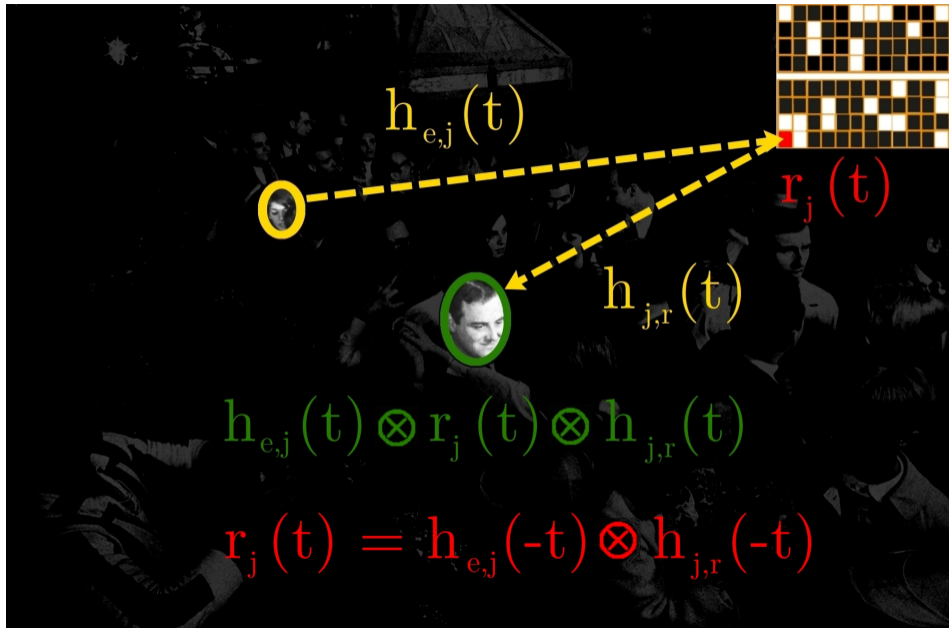
We try focusing acoustic waves in a broadband regime during my Ph.D.

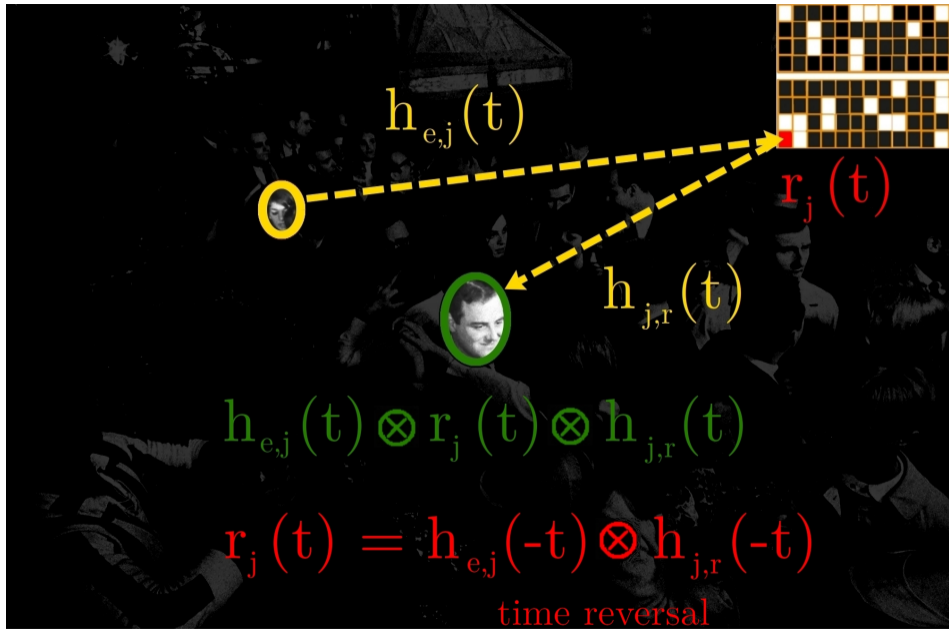




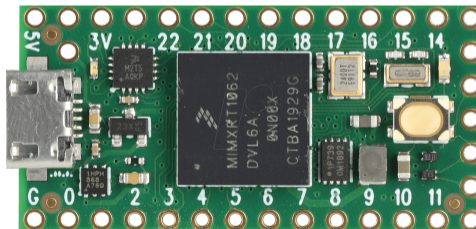
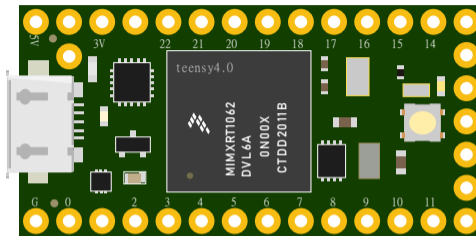




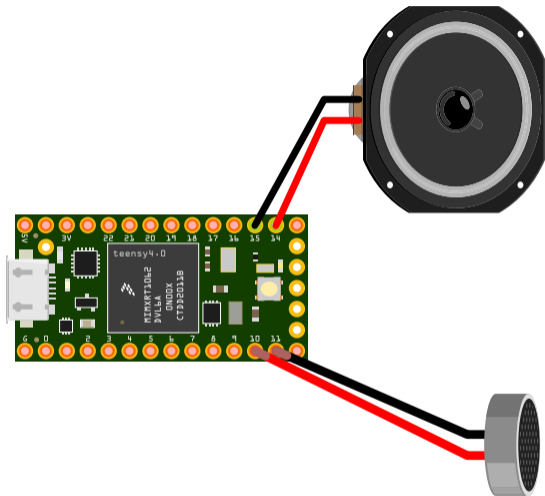


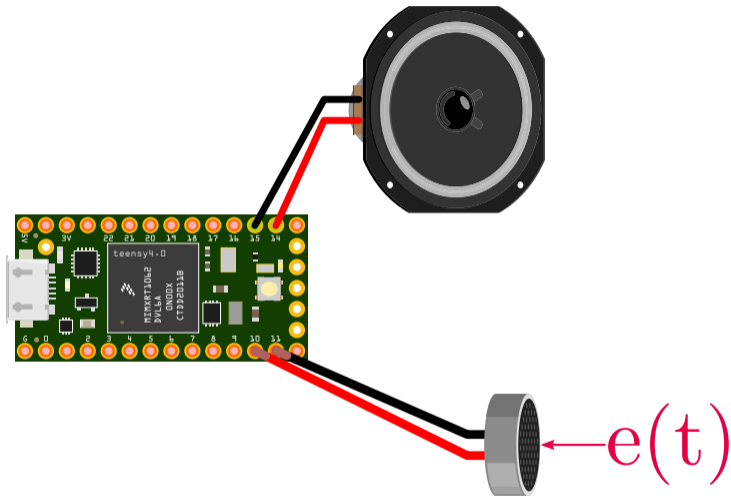


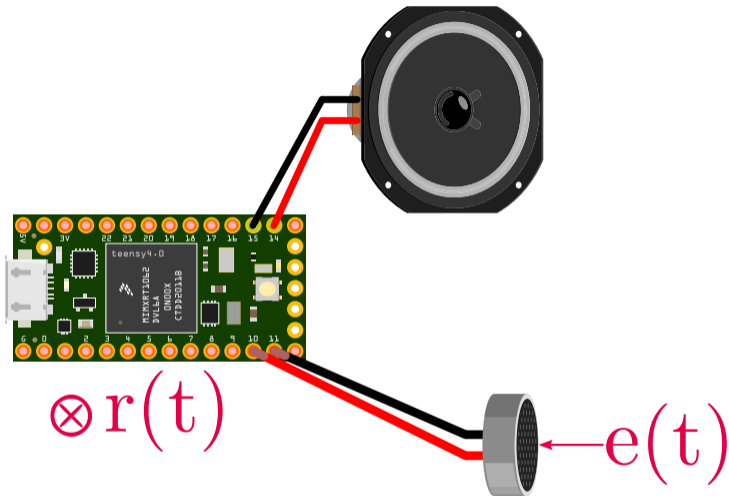
DESIGNING AN ACTIVE MIRROR

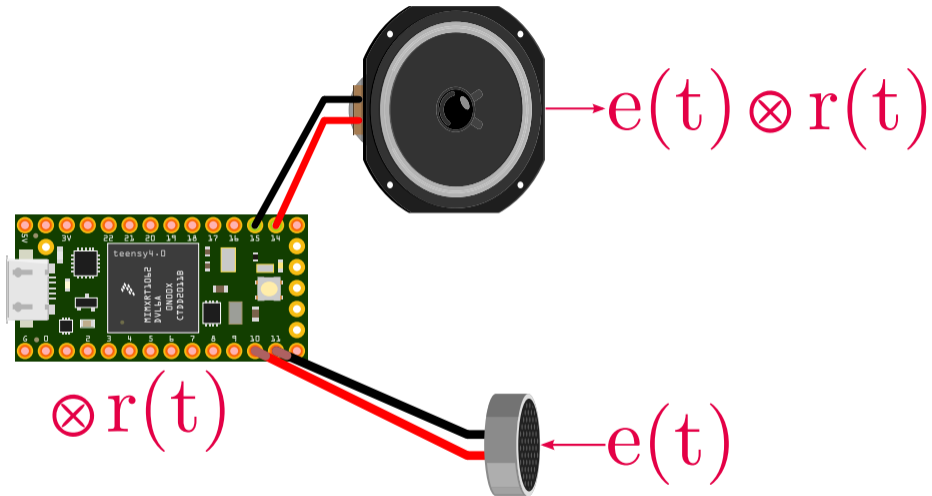


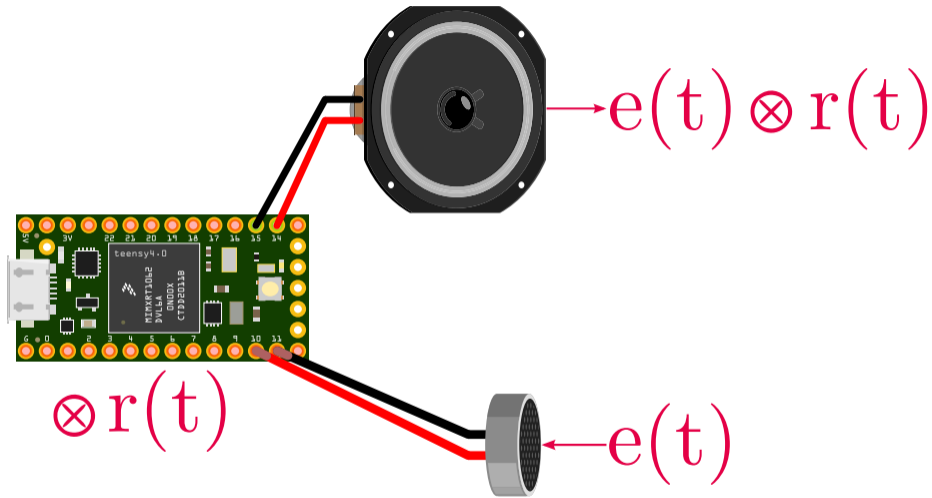
Arduino Teensy 4.0 performing digital convolution at 44.1 kHz.





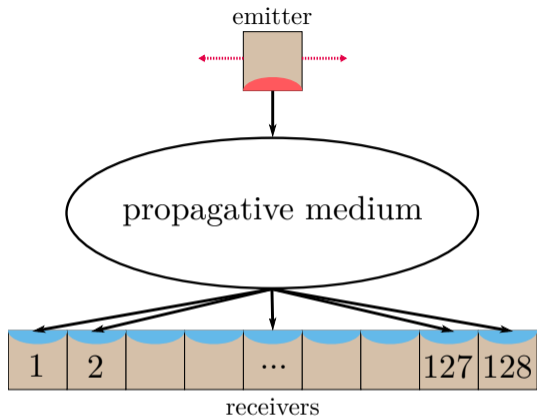


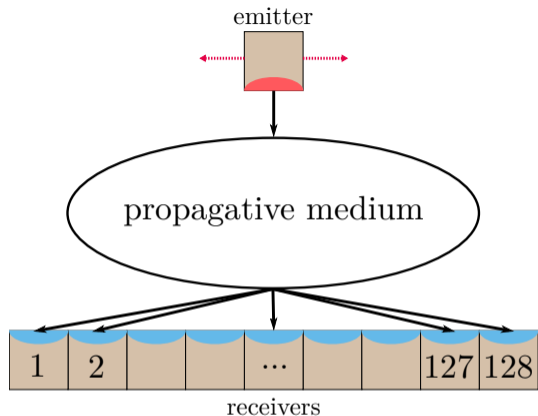




We are able to build a real time convolutive acoustic mirror.

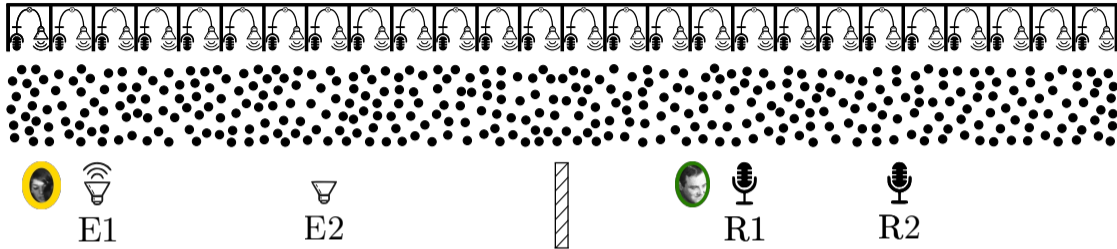




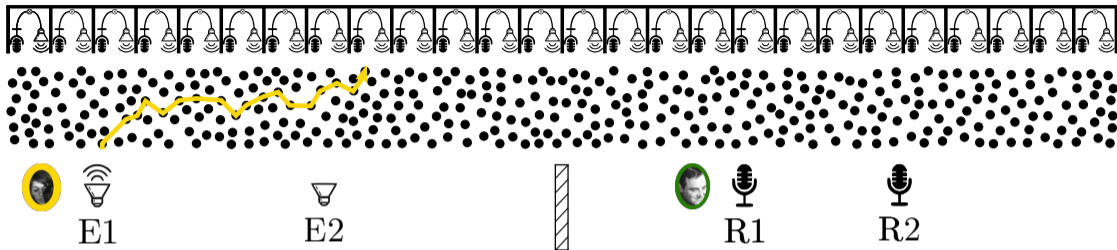


All Green's functions acquired and stored :
emitters to mirrors and mirrors to receivers.

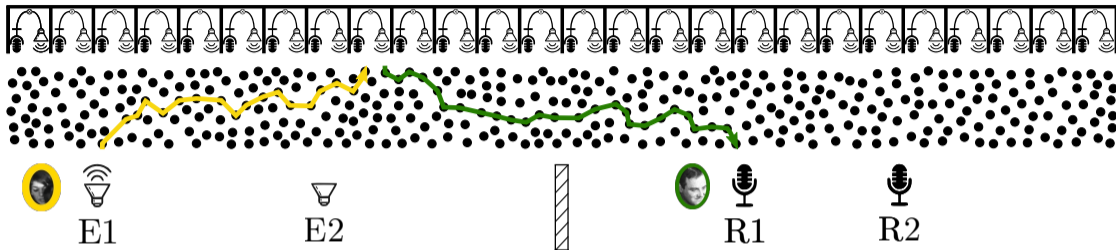
$$r_j(t)$$



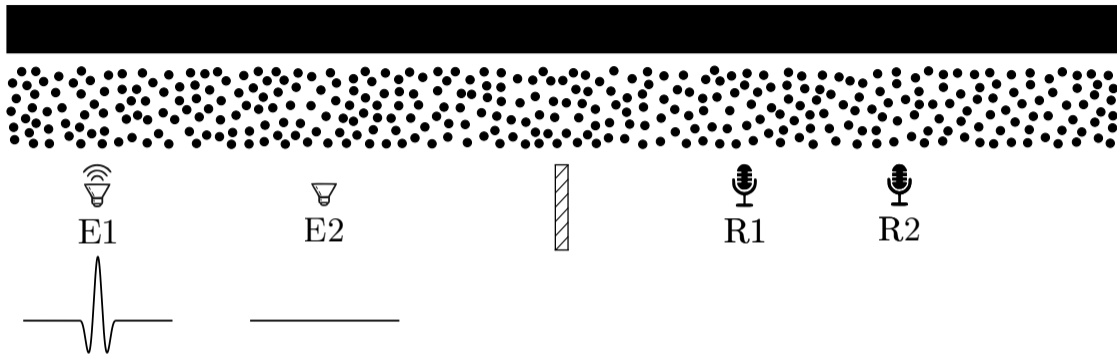
$$r_j(t)$$



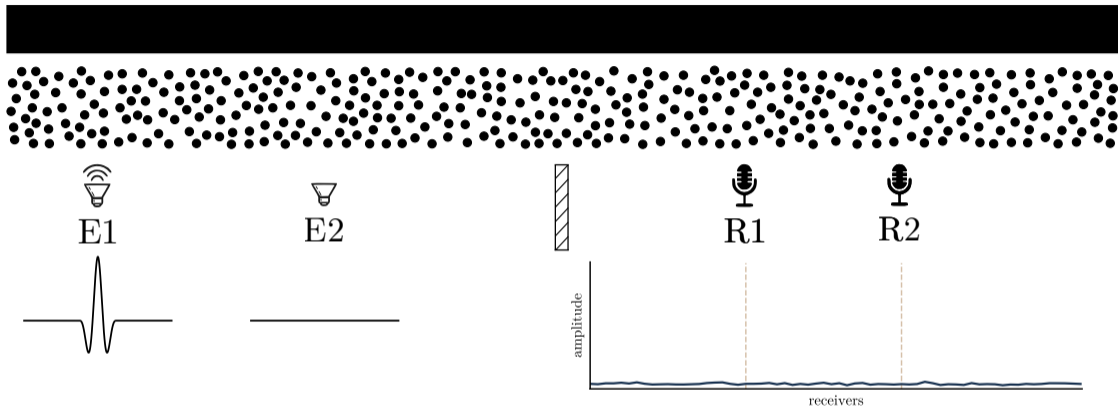
$$r_j(t)$$



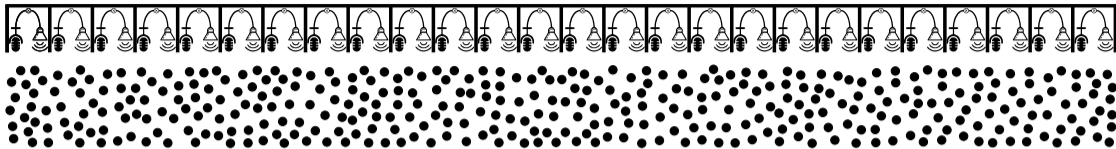
$$r_j(t) = \delta(t)$$



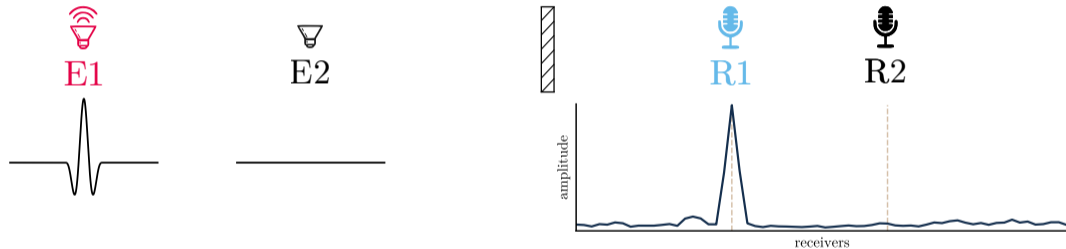
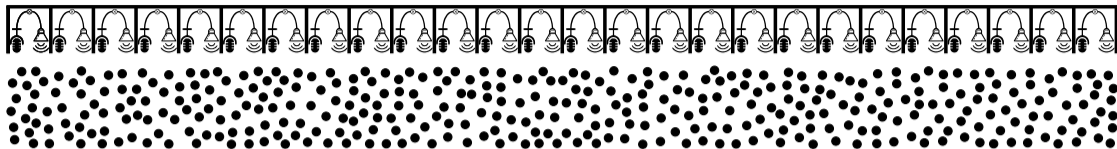
$$r_j(t) = \delta(t)$$



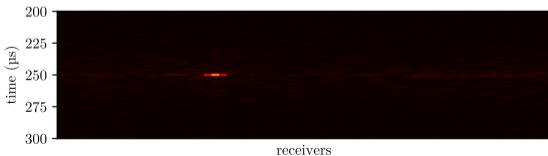
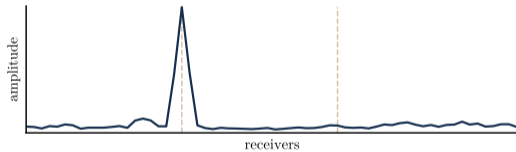
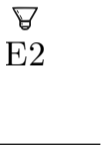
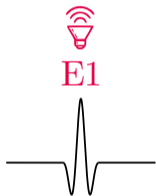
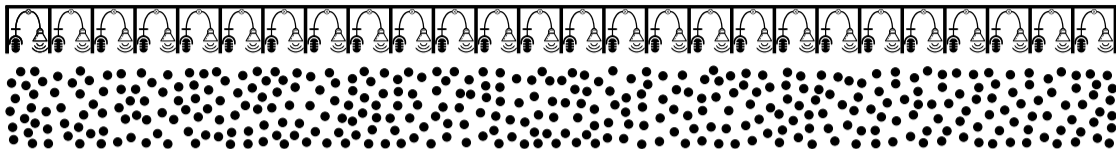
$$r_j(t) = h_{E1,j}(-t) \otimes h_{j,R1}(-t)$$



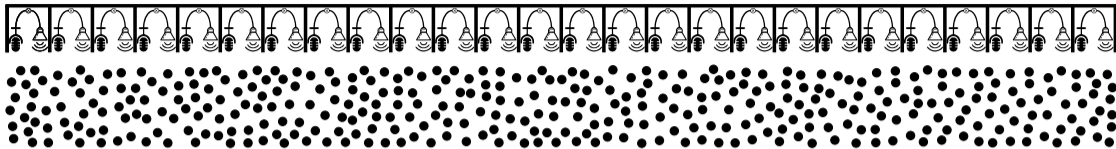
$$r_j(t) = h_{E1,j}(-t) \otimes h_{j,R1}(-t)$$



$$r_j(t) = h_{E1,j}(-t) \otimes h_{j,R1}(-t)$$



$$r_j(t) = h_{E2,j}(-t) \otimes h_{j,R1}(-t)$$



E1



E2



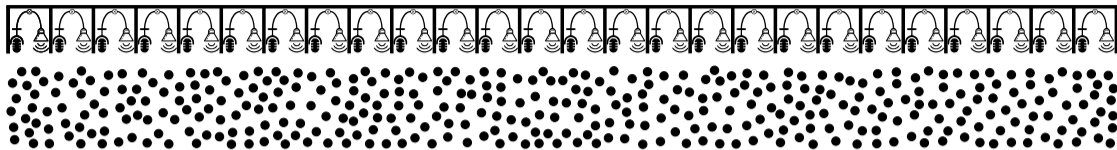
R1



R2



$$r_j(t) = h_{E2,j}(-t) \otimes h_{j,R1}(-t)$$



E1

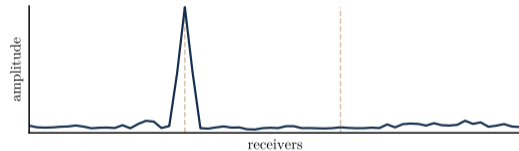


E2

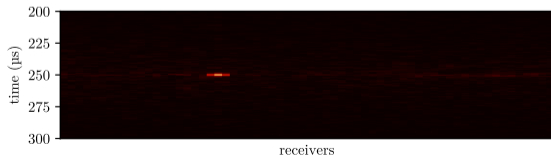
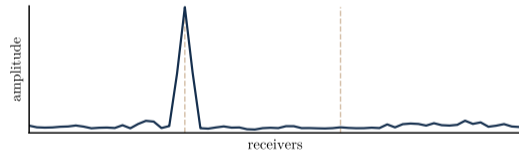
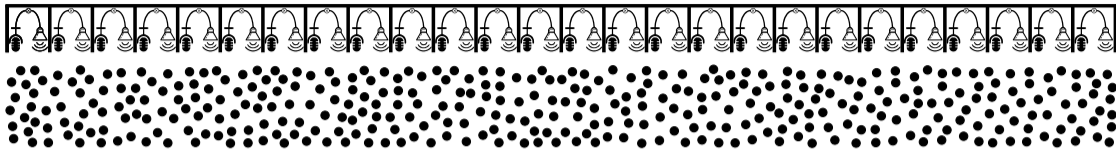


R1

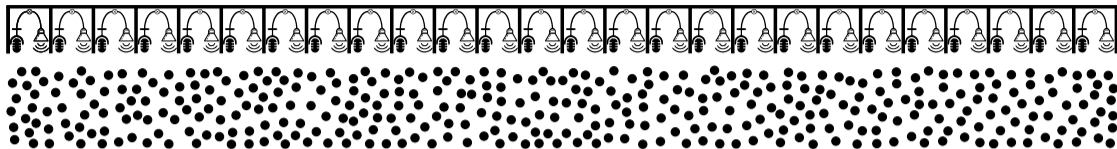
R2



$$r_j(t) = h_{E2,j}(-t) \otimes h_{j,R1}(-t)$$



$$r_j(t) = h_{E1,j}(-t) \otimes h_{j,R1}(-t)$$



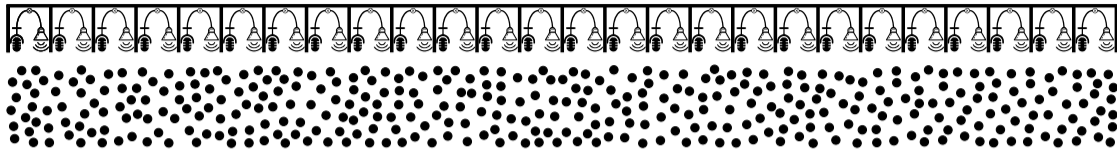
E1

E2

R1

R2

$$r_j(t) = h_{E1,j}(-t) \otimes h_{j,R1}(-t)$$



E1

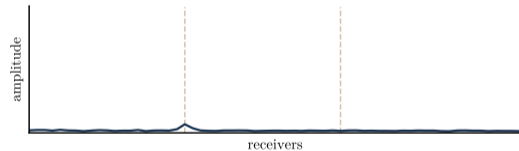


E2

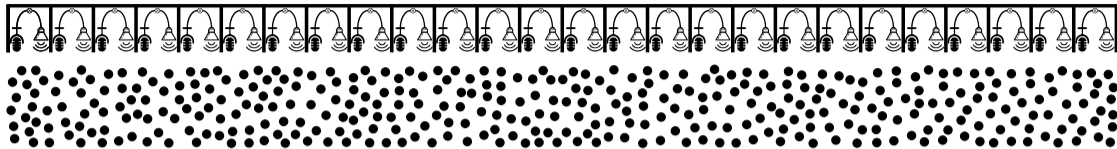


R1

R2



$$r_j(t) = h_{E1,j}(-t) \otimes h_{j,R1}(-t)$$



E1

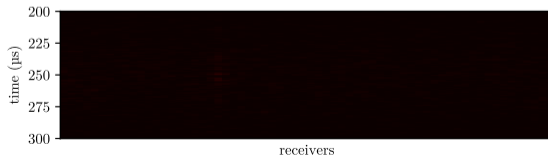
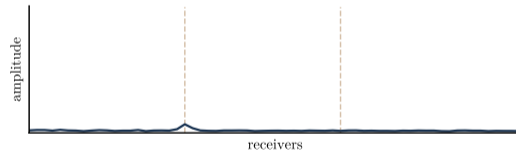


E2

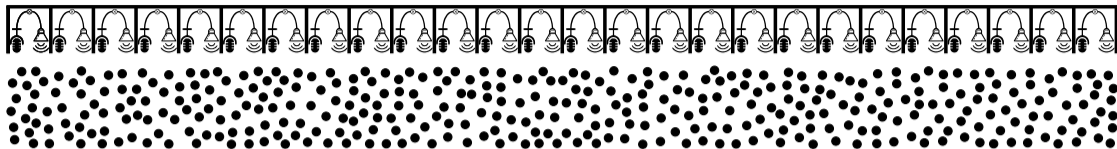


R1

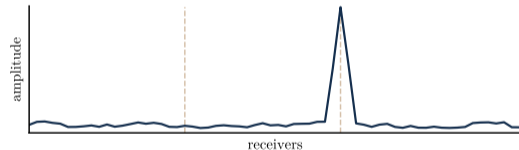
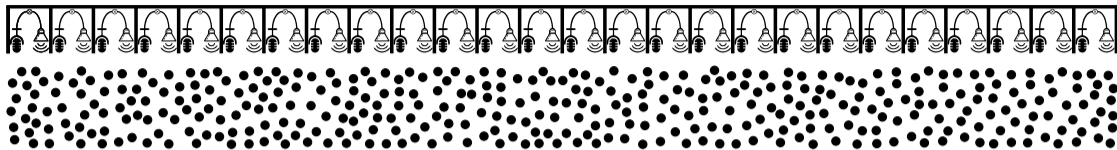
R2



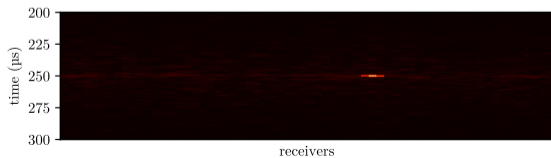
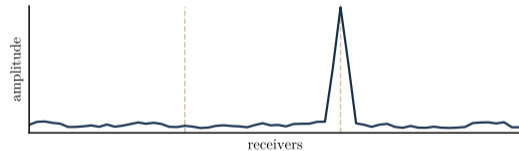
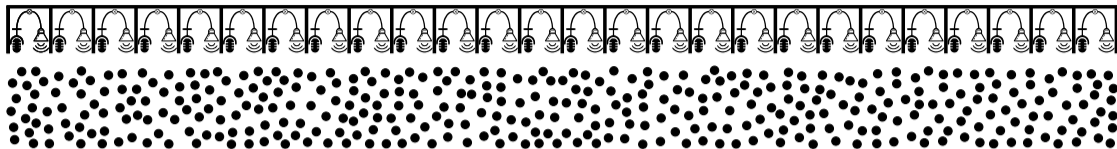
$$r_j(t) = h_{E2,j}(-t) \otimes h_{j,R2}(-t)$$



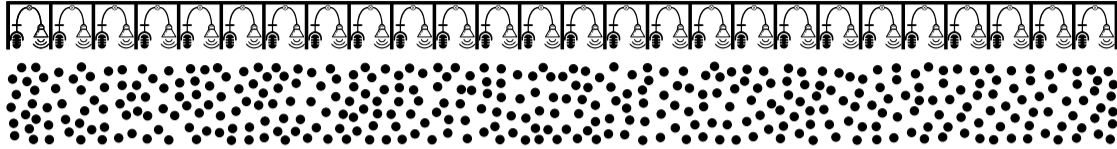
$$r_j(t) = h_{E2,j}(-t) \otimes h_{j,R2}(-t)$$



$$r_j(t) = h_{E2,j}(-t) \otimes h_{j,R2}(-t)$$



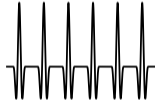
$$r_j(t) = h_{E1,j}(-t) \otimes h_{j,R1}(-t) + h_{E2,j}(-t) \otimes h_{j,R2}(-t)$$



E1



E2

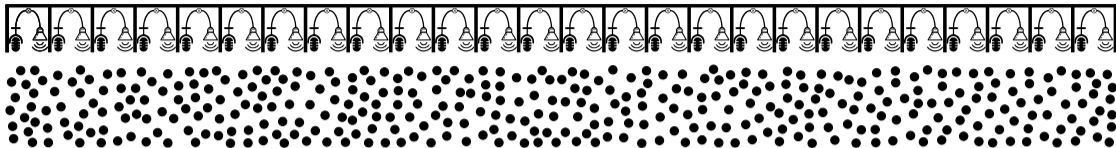


R1



R2

$$r_j(t) = h_{E1,j}(-t) \otimes h_{j,R1}(-t) + h_{E2,j}(-t) \otimes h_{j,R2}(-t)$$



E1



E2

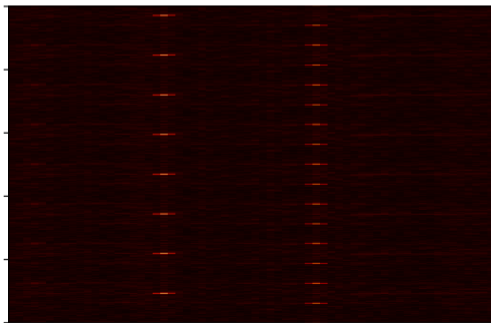


R1



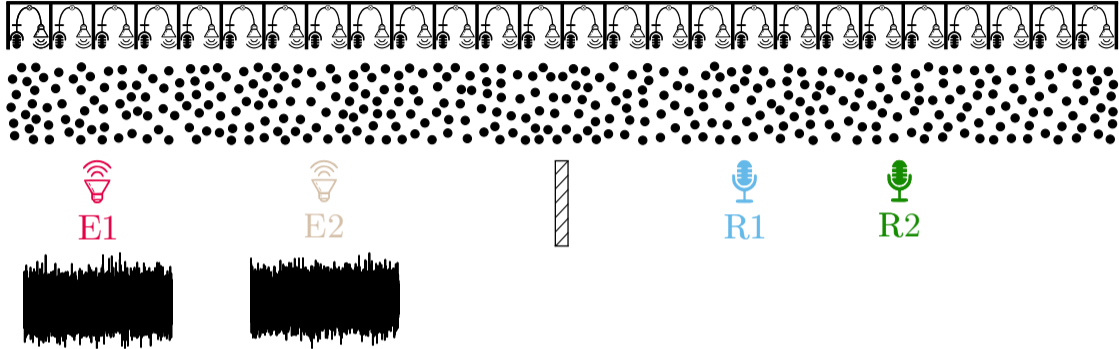
R2

0
100
200
300
400
500
time (μ s)

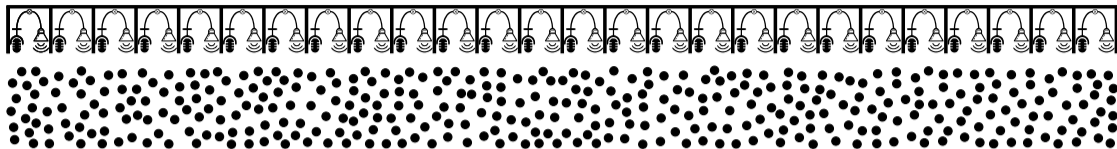


receivers

$$r_j(t) = h_{E1,j}(-t) \otimes h_{j,R1}(-t) + h_{E2,j}(-t) \otimes h_{j,R2}(-t)$$



$$r_j(t) = h_{E1,j}(-t) \otimes h_{j,R1}(-t) + h_{E2,j}(-t) \otimes h_{j,R2}(-t)$$



E1



E2



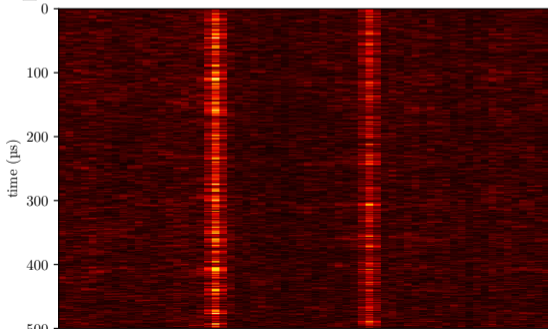
0



R1

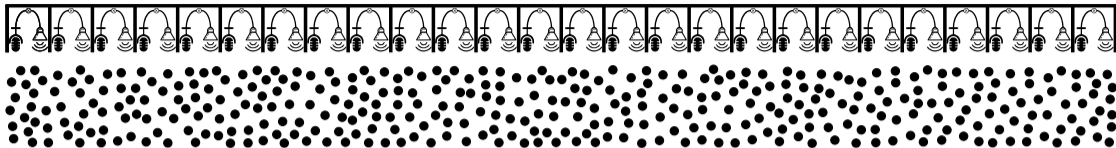


R2



receivers

$$r_j(t) = h_{E1,j}(-t) \otimes h_{j,R1}(-t) + h_{E2,j}(-t) \otimes h_{j,R2}(-t)$$



E1



E2



0



R1



R2

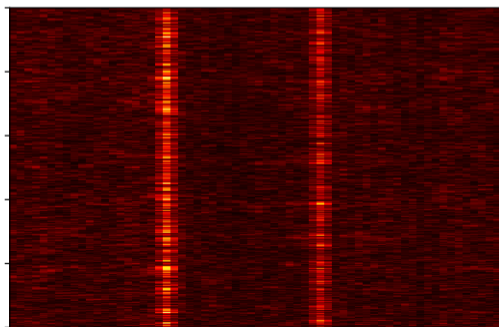
time (μ s)

200

300

400

500

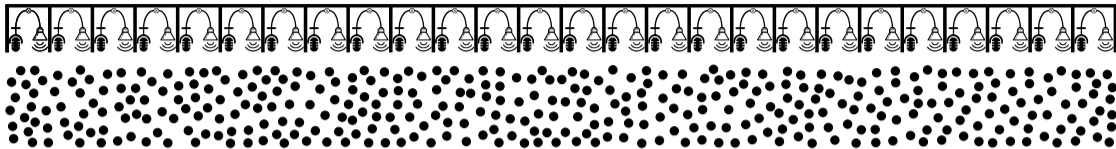


receivers

Correlation's coefficient

$$\frac{S_{Ri}(t) \otimes S_{Ek}(-t)}{\sqrt{\sum_t |S_{Ri}(t)|^2} \cdot \sqrt{\sum_t |S_{Ek}(t)|^2}}$$

$$r_j(t) = h_{E1,j}(-t) \otimes h_{j,R1}(-t) + h_{E2,j}(-t) \otimes h_{j,R2}(-t)$$



E1



E2



R1



R2



0

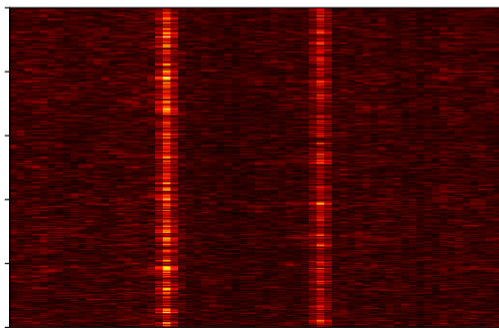
100

200

300

400

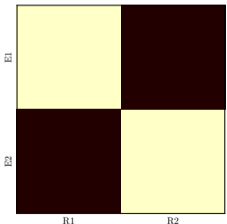
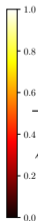
500

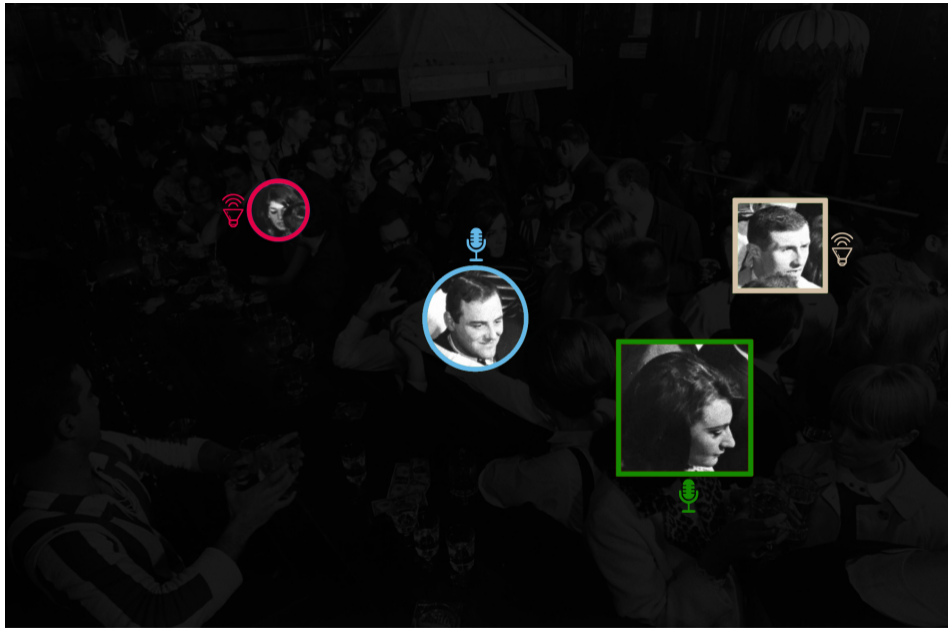


receivers

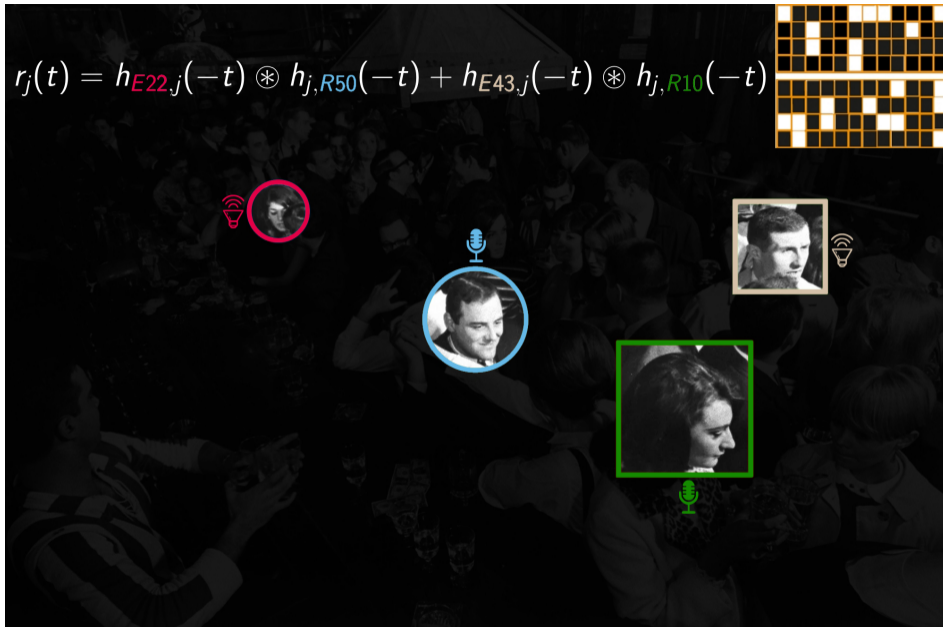
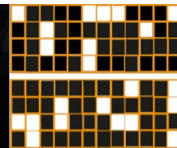
Correlation's coefficient

$$\frac{S_{Ri}(t) \otimes S_{Ek}(-t)}{\sqrt{\sum_t |S_{Ri}(t)|^2} \cdot \sqrt{\sum_t |S_{Ek}(t)|^2}}$$

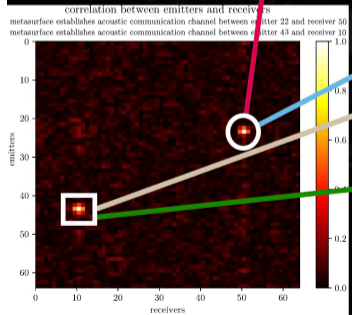
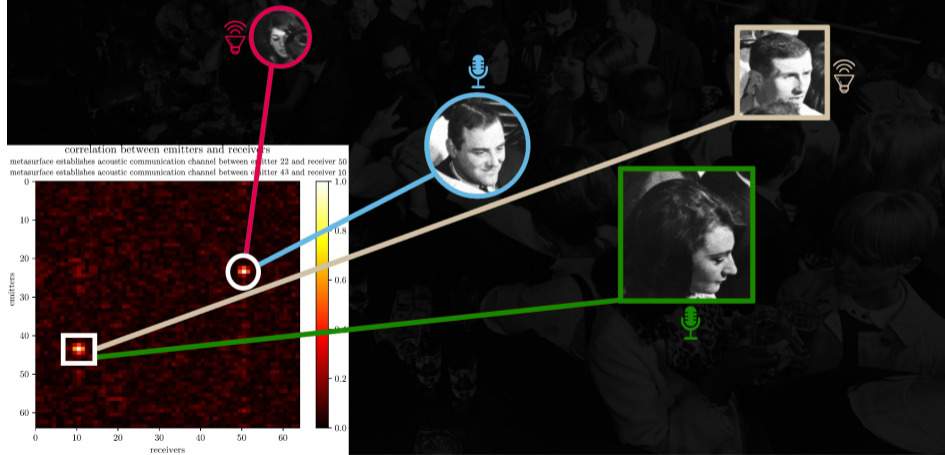
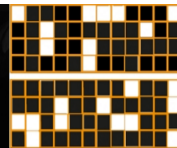




$$r_j(t) = h_{E22,j}(-t) \otimes h_{j,R50}(-t) + h_{E43,j}(-t) \otimes h_{j,R10}(-t)$$



$$r_j(t) = h_{E22,j}(-t) \otimes h_{j,R50}(-t) + h_{E43,j}(-t) \otimes h_{j,R10}(-t)$$



WORK IN PROGRESS

Build the acoustic metasurface.

Try a time reversal configuration in real time.

Design optimal temporal convolution filters.

Thank you for your attention

constant.bourdeloux@espci.psl.eu