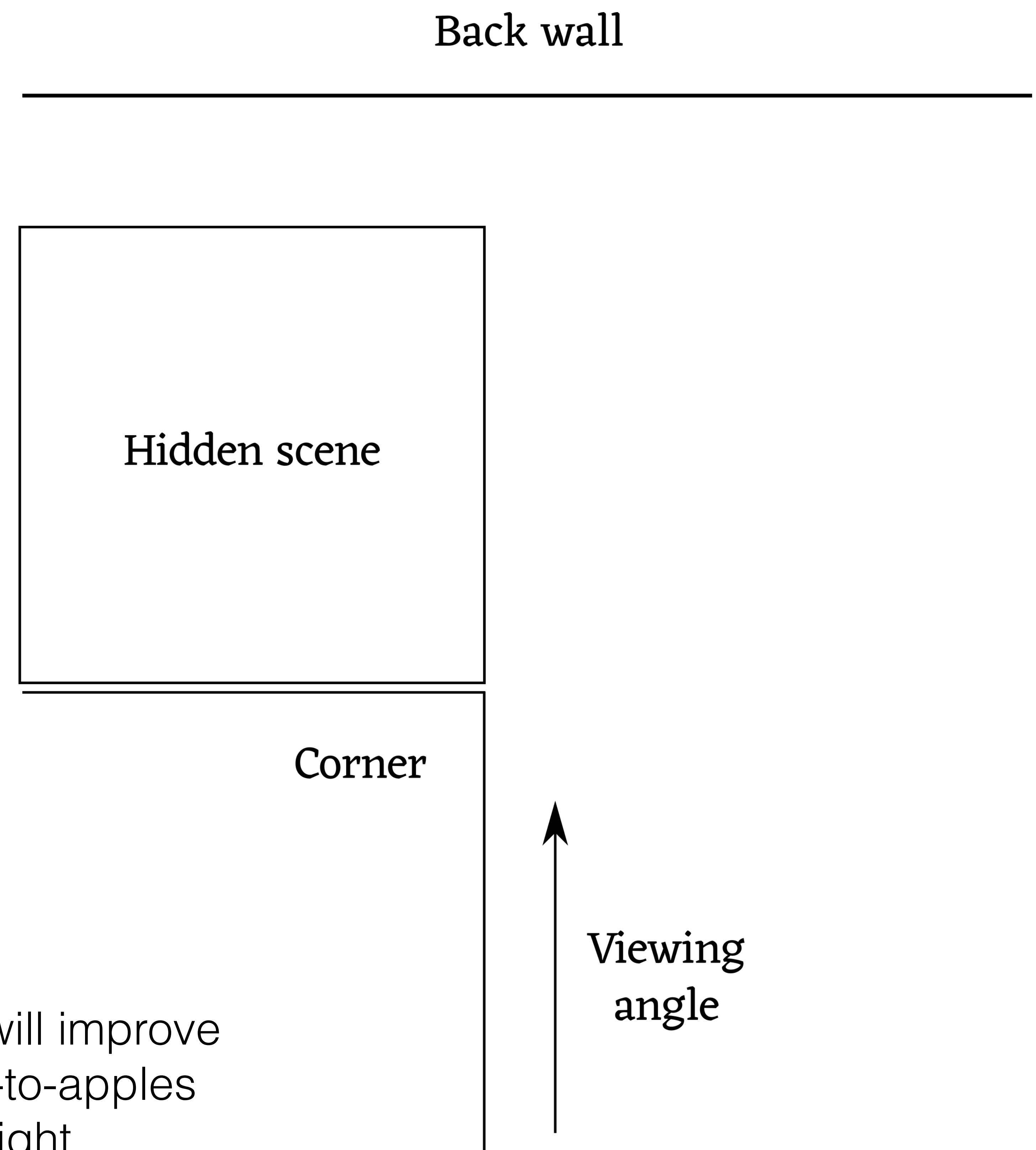
When peering into a room partly hidden by a corner (or other wall), we can make use of that corner to infer information about the hidden scene. The occlusion from the corner makes the reconstruction problem better-conditioned.

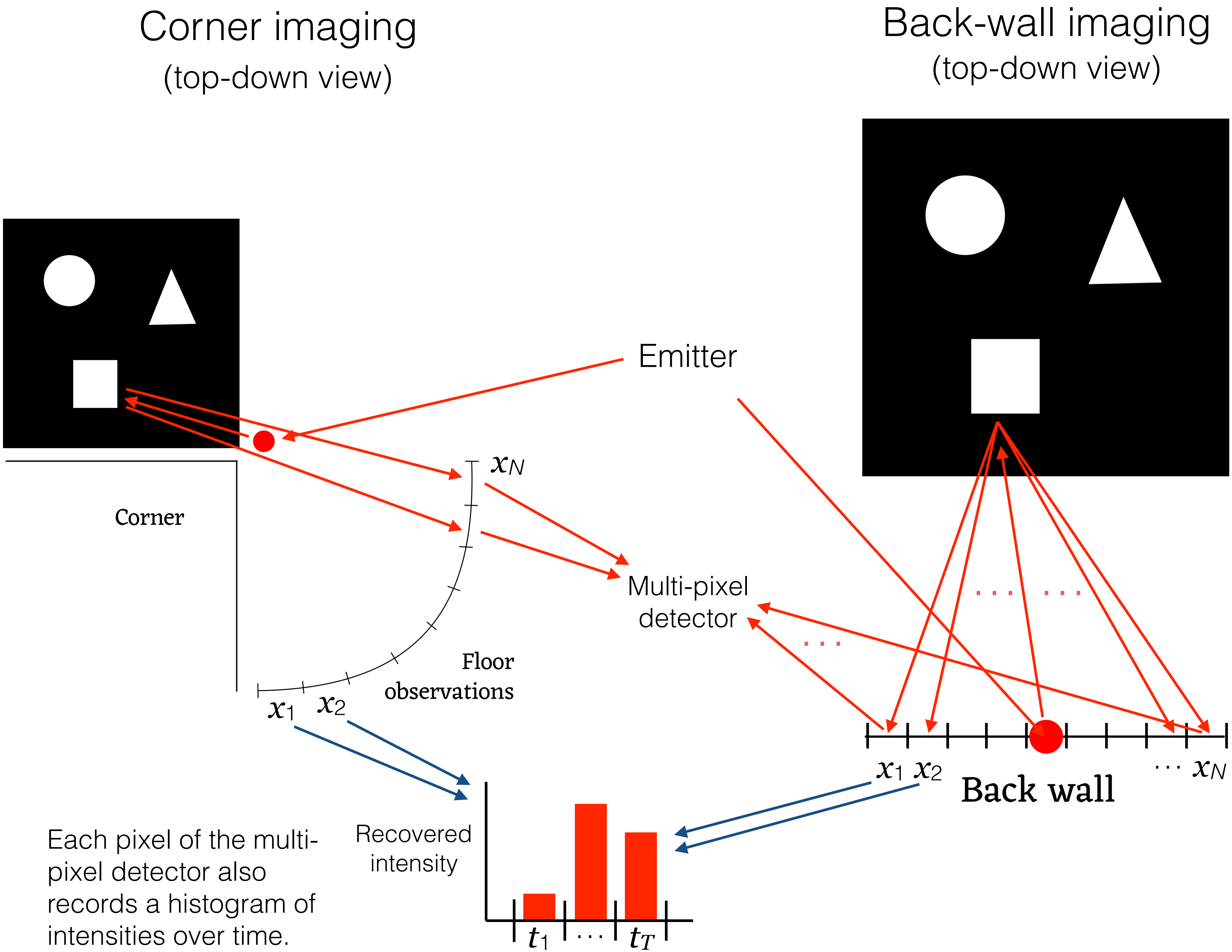
We believe that this specific scenario lends itself particularly well to a hybrid active-passive approach. Introducing time-of-flight information into the problem yields two benefits:

-We can image static scenes
-We gain a second dimension in our reconstructions (depth)

Top-down view of the imaging setup



Obviously, introducing time-of-flight will improve reconstruction quality. For an apples-to-apples comparison, we compare a time-of-flight approach that makes use of the corner to one that makes use of the back wall.



Corner imaging
(top-down view)
Back-wall imaging
(top-down view)
Emitter
Corner
x_N
Multi-pixel
detector
Floor
observations
x_1 x_2
x_1 x_2
$\cdots$ x_N
Back wall
Recovered
intensity
t_1 $\cdots$ t_T
Each pixel of the multi-pixel detector also records a histogram of intensities over time.

Transfer matrix

N: # of pixels on multi-pixel detector
(spatial resolution)

T: # of buckets in time histogram
(temporal resolution)

M: # of pixels in the scene
(simulation parameter)

Each matrix column corresponds to the impulse response from one point in the scene.

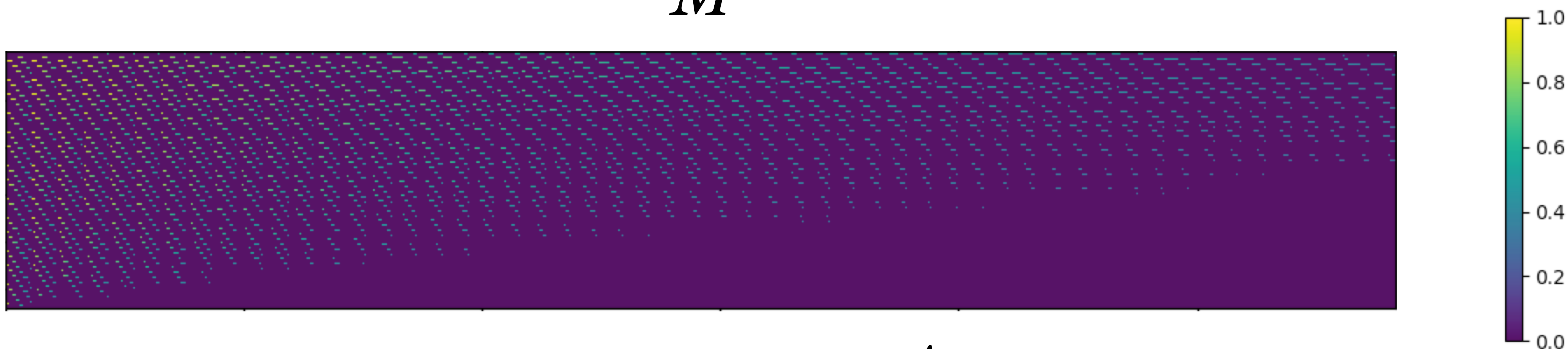
Each matrix row corresponds to the observations recorded from at one bar of the time-histogram from a single spatial observation.

Matrix entries take a value of 0 if the no light from that part of the scene returns at that time and space.

Otherwise matrix entries take a non-zero value.

M

NT



The transfer matrix A

Vector of spatio-temporal observations

Vectorized scene

Poisson noise

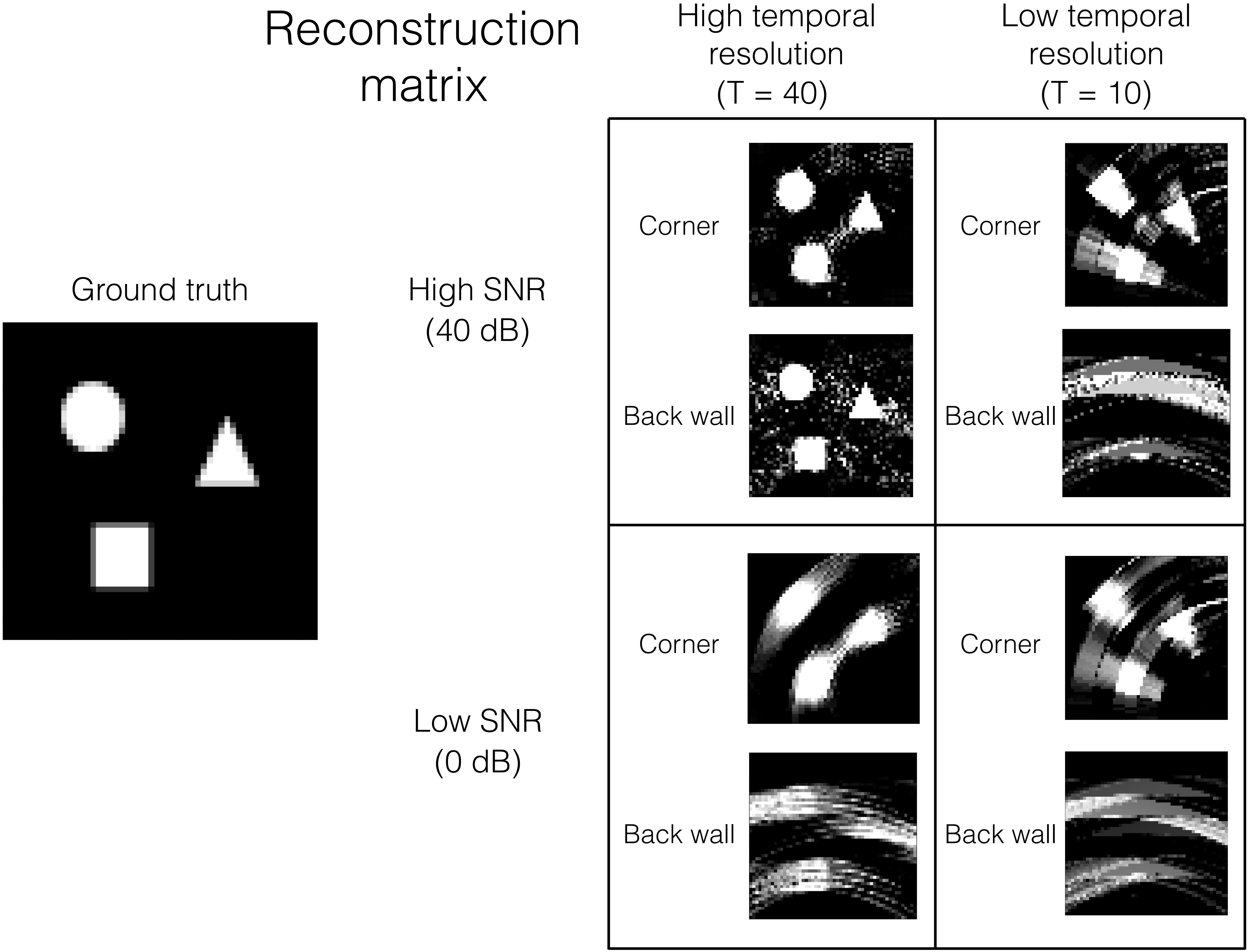
$$y = Ax + \eta$$

SNR

Reconstructed scene

Scene prior covariance matrix

$$\hat{x} = \gamma^{-1}A^T(\gamma AQA^T + I)^{-1}y$$


Reconstruction matrix
High temporal resolution (T = 40)
Low temporal resolution (T = 10)
Ground truth
High SNR (40 dB)
Low SNR (0 dB)
Corner
Back wall
Corner
Back wall
Corner
Back wall
Corner
Back wall