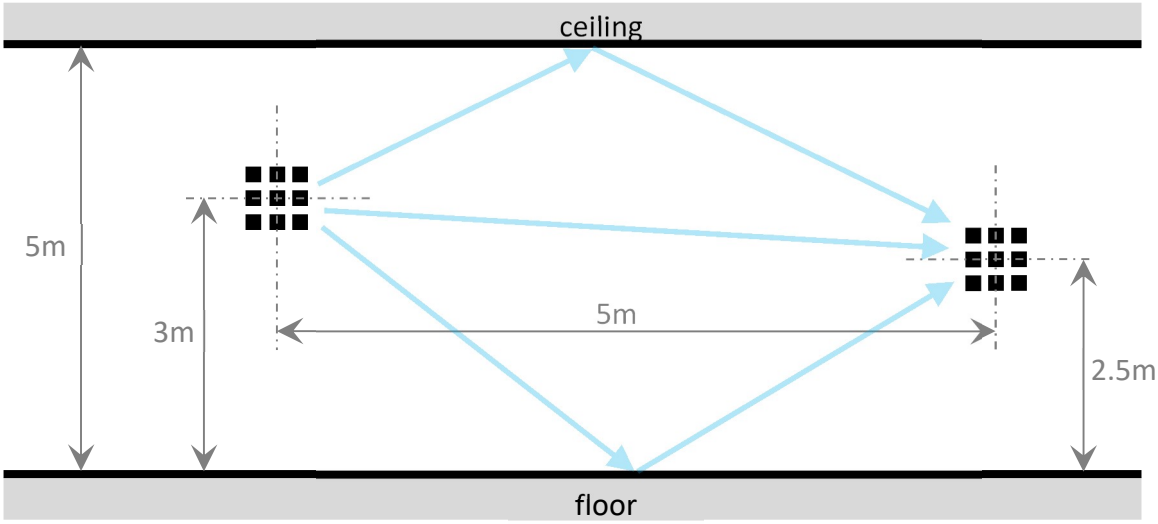
Problem A4: Using MIMO on the Indoor Three-Path Channel

Disclaimer: Before working on this topic, make sure that you have finished and fully understood Exercise 1 “Frii's Equation and Two-Ray Model” and the provided solution.

We consider a 9 x 9 MIMO system operating in the following indoor three-path propagation environment:



The two grids show the TX and RX antenna arrays, respectively. The floor and ceiling have a reflection coefficient of -1. The system uses a carrier frequency of 5 GHz.

First, we assume an antenna spacing (spacing between) of 30 mm.

- **Q1:** Compute the channel matrix $\mathbf{H}$ from the geometry of the link and the environment (this task is analogous to exercise Problem 1.5, but has to be repeated 81 times to calculate all the entries of the channel matrix).
- **Q2:** Evaluate the eigenvalues of $\mathbf{H}\mathbf{H}^{\mathrm{H}}$. What do you observe? Interpret!
- **Q3:** Repeat Q2 for an antenna spacing of 1 mm and interpret the result.
- **Q4:** Repeat Q2 for a horizontal TX-RX distance of 100 m (instead of the specified 5 m) and interpret the result.
- **Q5:** Do you think spatial multiplexing is feasible in the scenarios of Q3 and Q4? How would a zero-forcing equalizer perform?

The signal and noise power shall be chosen such that the SNR of a free-space SISO link over the same distance would be 7 dB.

- **Q6:** Compute the achievable rate of the MIMO system without CSIT.
- **Q7:** Plot the achievable rate as a function of the antenna spacing (sweep from 1mm to 600 mm) and interpret the result.