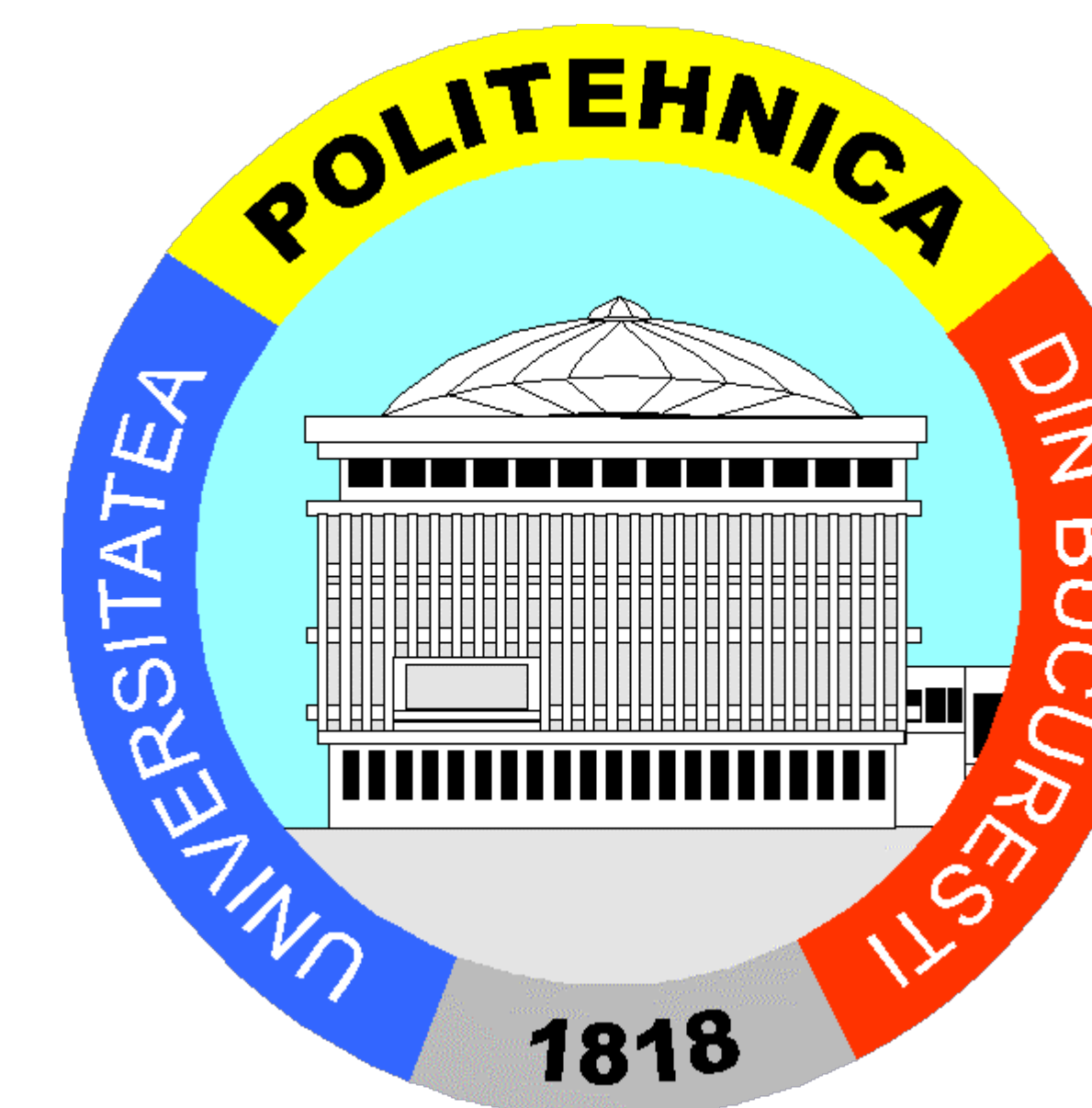


Finding MIMO

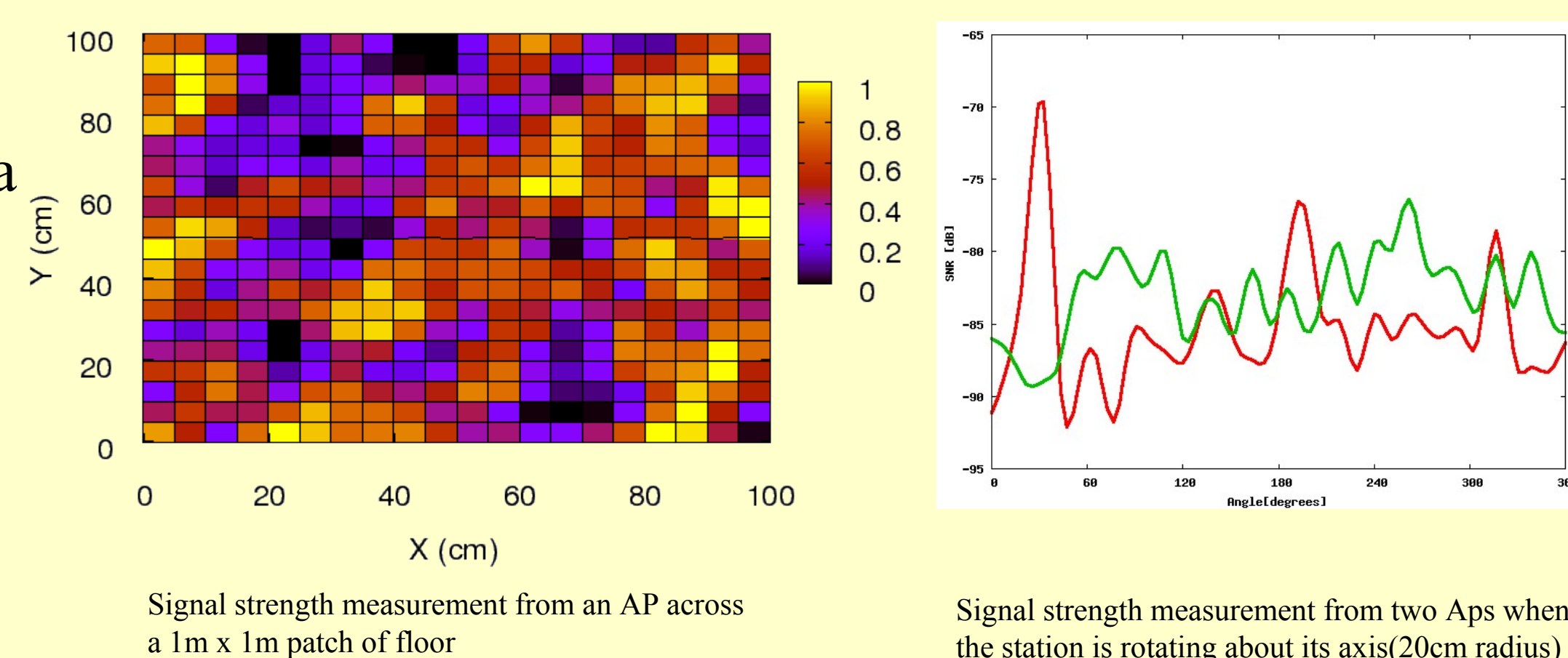


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Motivation

Indoor networking facts

- signal quality varies with user location & antenna position
- human activity level affects signal map

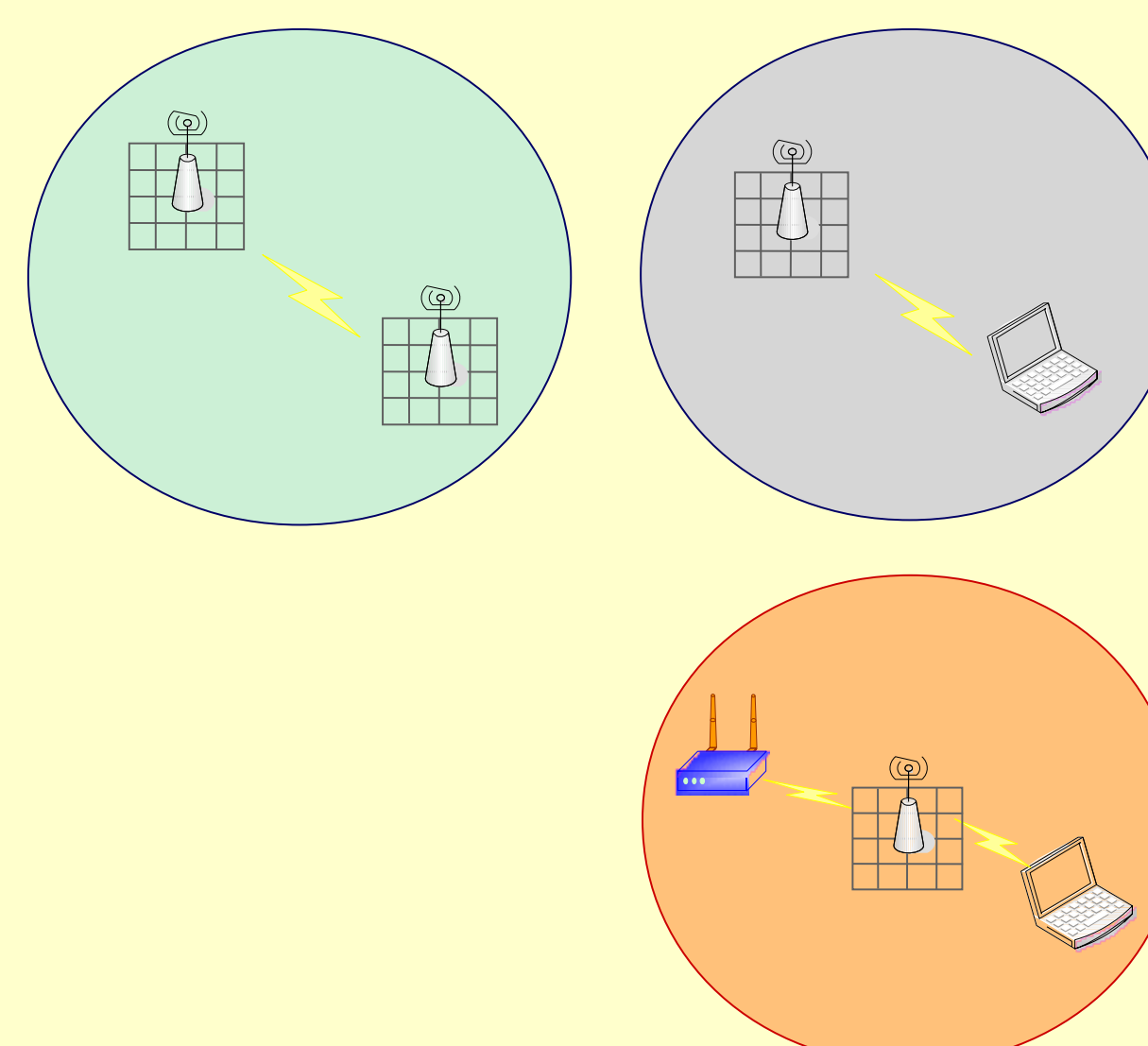


Outdoor networking facts

- point to point propagation varies in time
- long term links require manual tuning, maintenance

Basic idea: counter environment changes with mechanical changes in the antenna system

- ceiling mounted access points have motors that allow changing of the antenna positions on a centimetre scale
- exploit spatial diversity by physically trying different antenna positions
- exploration of the parameter space to improve coverage/throughput/interference



Implementation (USRP)

Hardware: USRP (Universal Software Radio Peripheral)

Implementation based on blocks in the gnuradio library

- BPSK at 1Mbps on each antenna

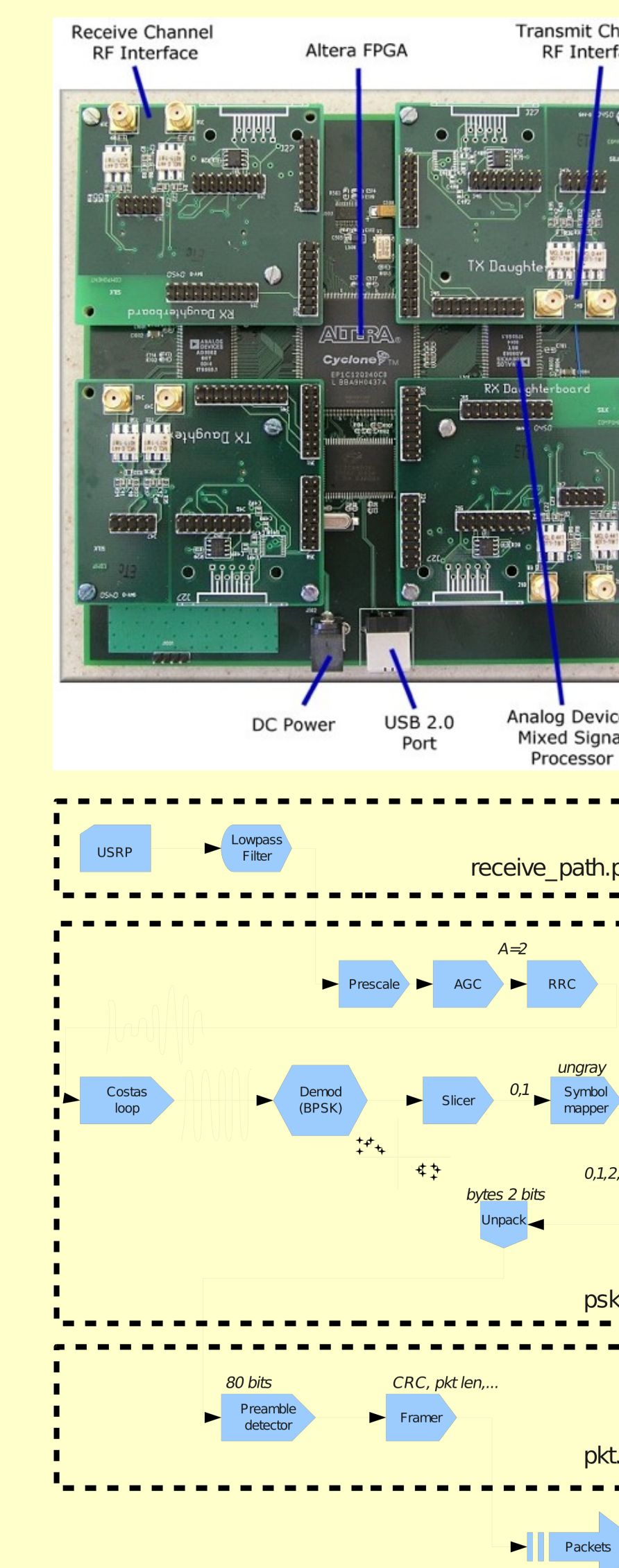
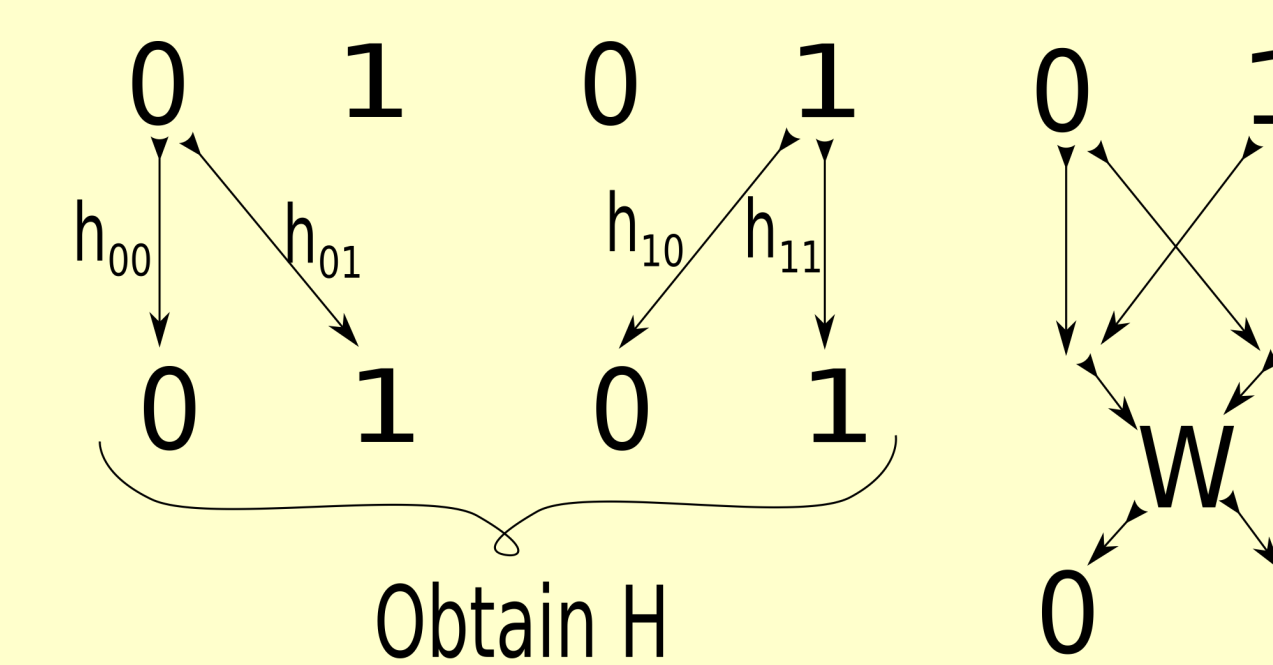
Measurement method

- Send stream from antenna 0, keep antenna 1 inactive
- measure h_{00} and h_{01} at 0 and 1 respectively

$$y_0 = x_0 h_{00} + n_0$$

$$y_1 = x_0 h_{01} + n_1$$

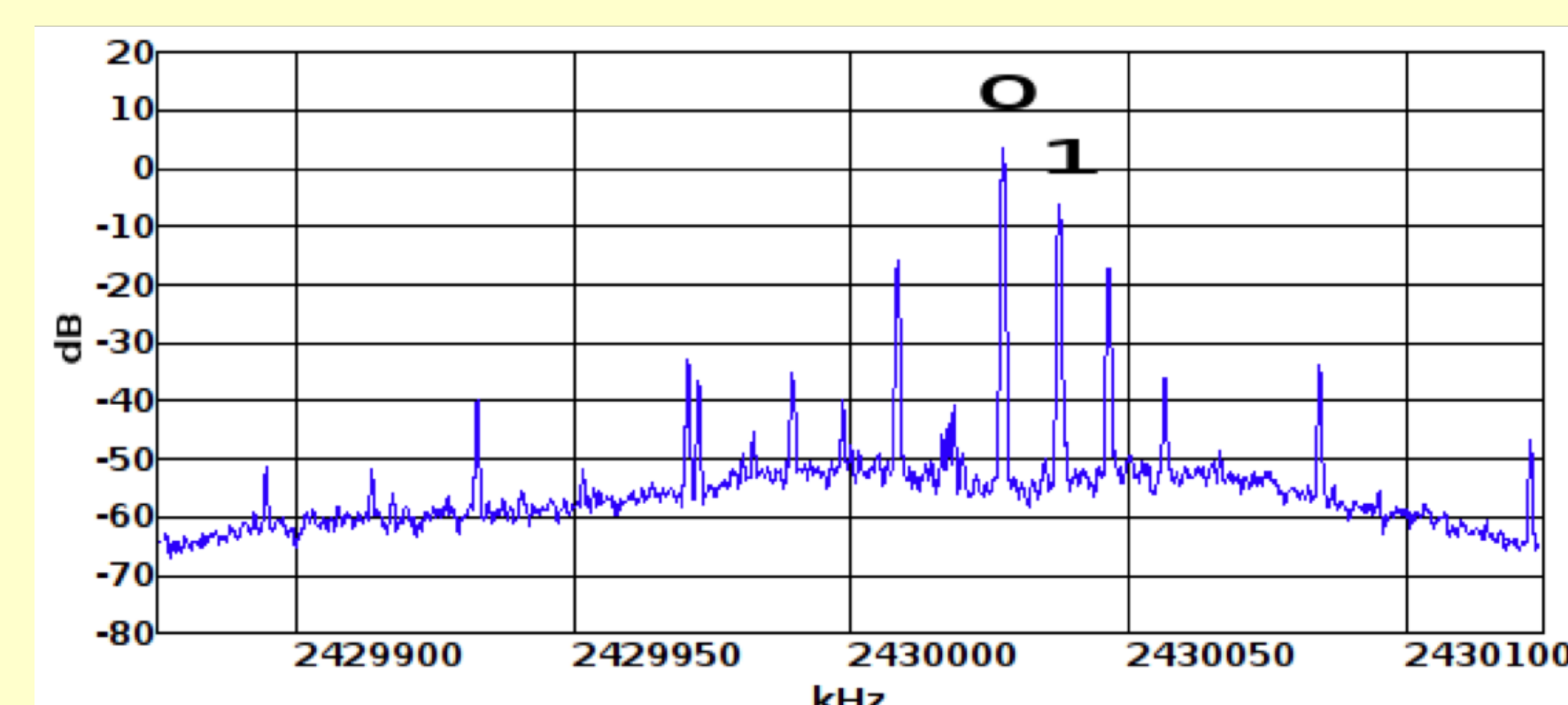
$$h_{00} = P_{00} \text{mean}(y_0 / x_0), \dots$$



How it works

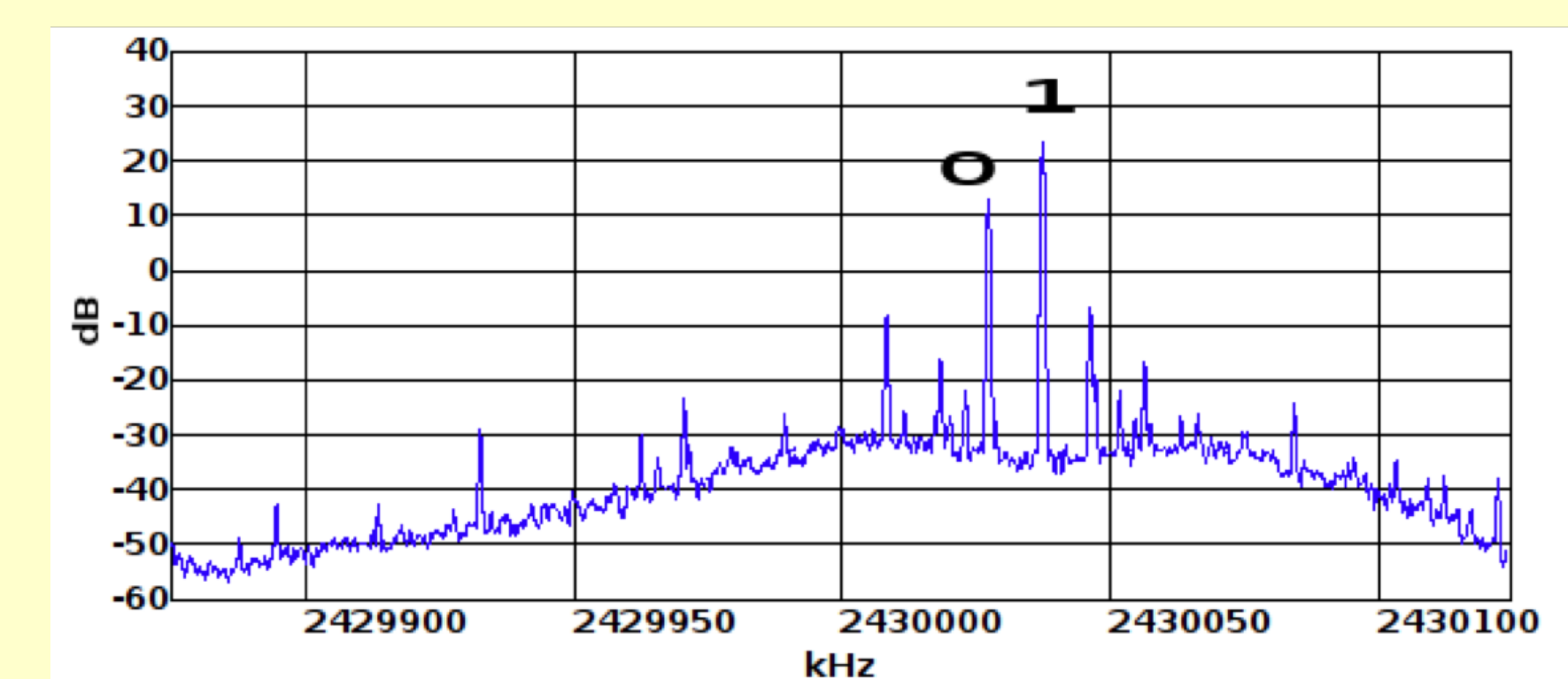
One antenna systems

- motorized antenna explores space for better signal strength



2 x 2 antenna system (MIMO)

- sender: each antenna generates a different tone
- receiver:
 - each antenna position is optimized independently
 - for example: antenna 0 searches for a position that maximizes power from tone 0 and minimizes power from tone 1
 - ZF channel estimation



Measurement results

how easy can we find independent channels?

- explore a 500cm² area with one antenna
- histogram below: 11% of the points exhibit more than 10dB absolute difference in the power received from the two sender antennas
- graph below: gain difference across the entire area

actual output at two different positions of the receiver antennas

- upper right: decorrelated channels (200% throughput on 2x2 system)
- lower right: channels with some correlation

