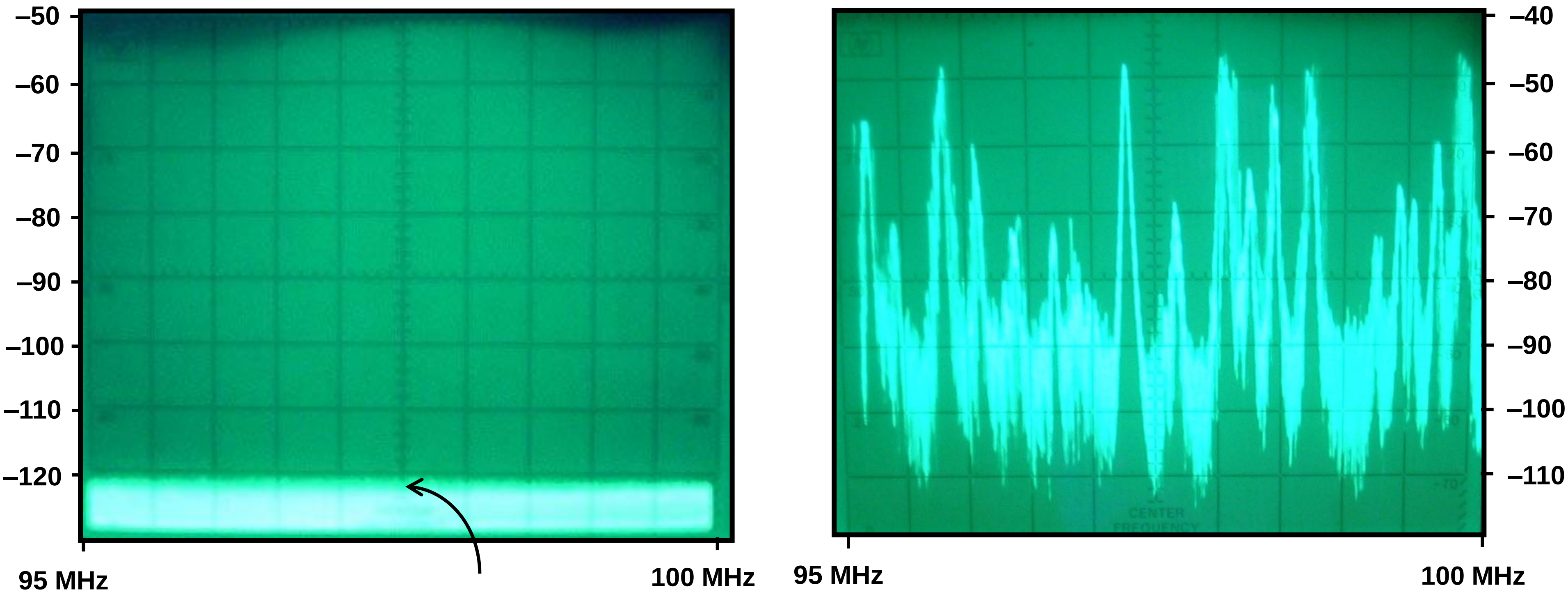
3.4 *Direct signal cancellation*

1. Direct signal and noise levels
2. Noise and interference as a function of angle and frequency
3. Suppression methods

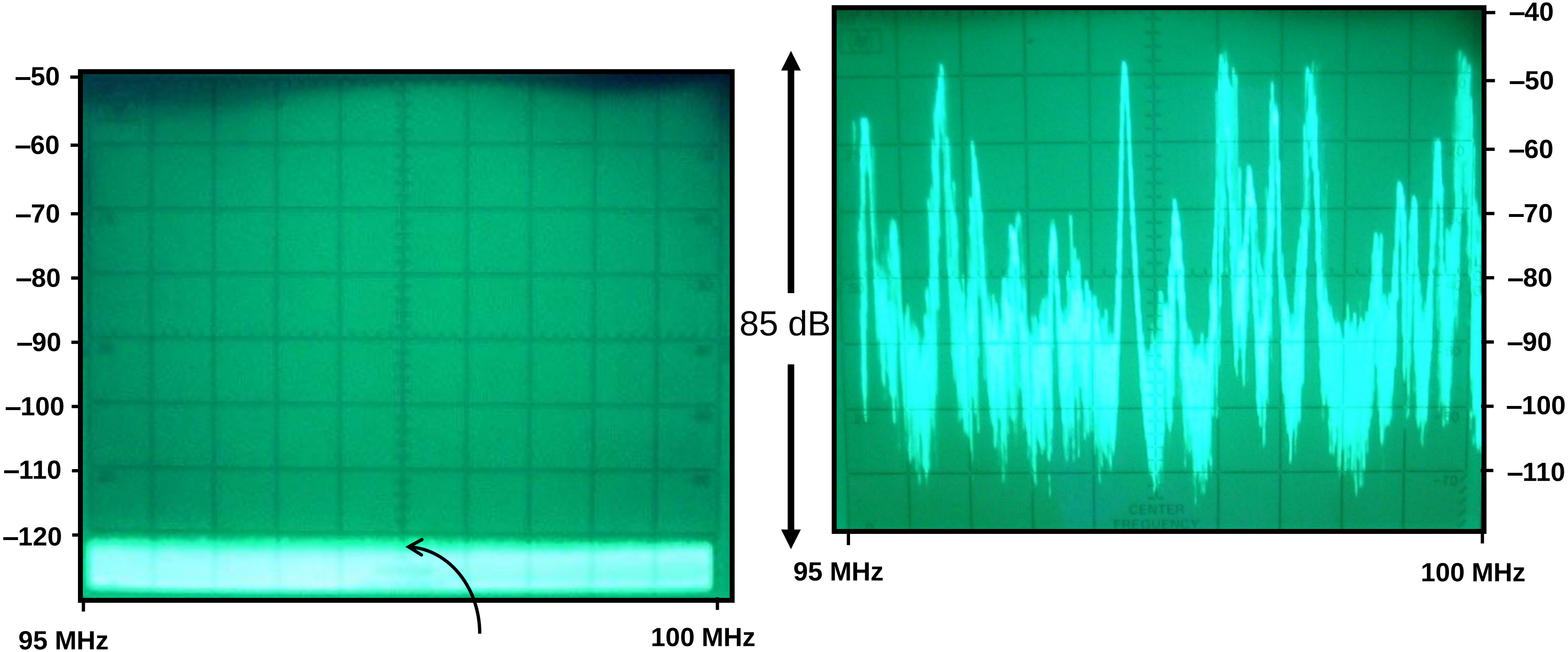
Noise level



$P_n = kT_0BF$ = –122 dBm in B = 50 kHz

Noise levels in a passive radar receiver in FM radio band: (i) thermal noise in 50 kHz bandwidth corresponding to 5 dB receiver noise figure; top of screen = –50 dBm (ii) signal and noise levels measured from 10th floor of UCL in Central London on vertically-polarised dipole antenna; top of screen = –40 dBm.

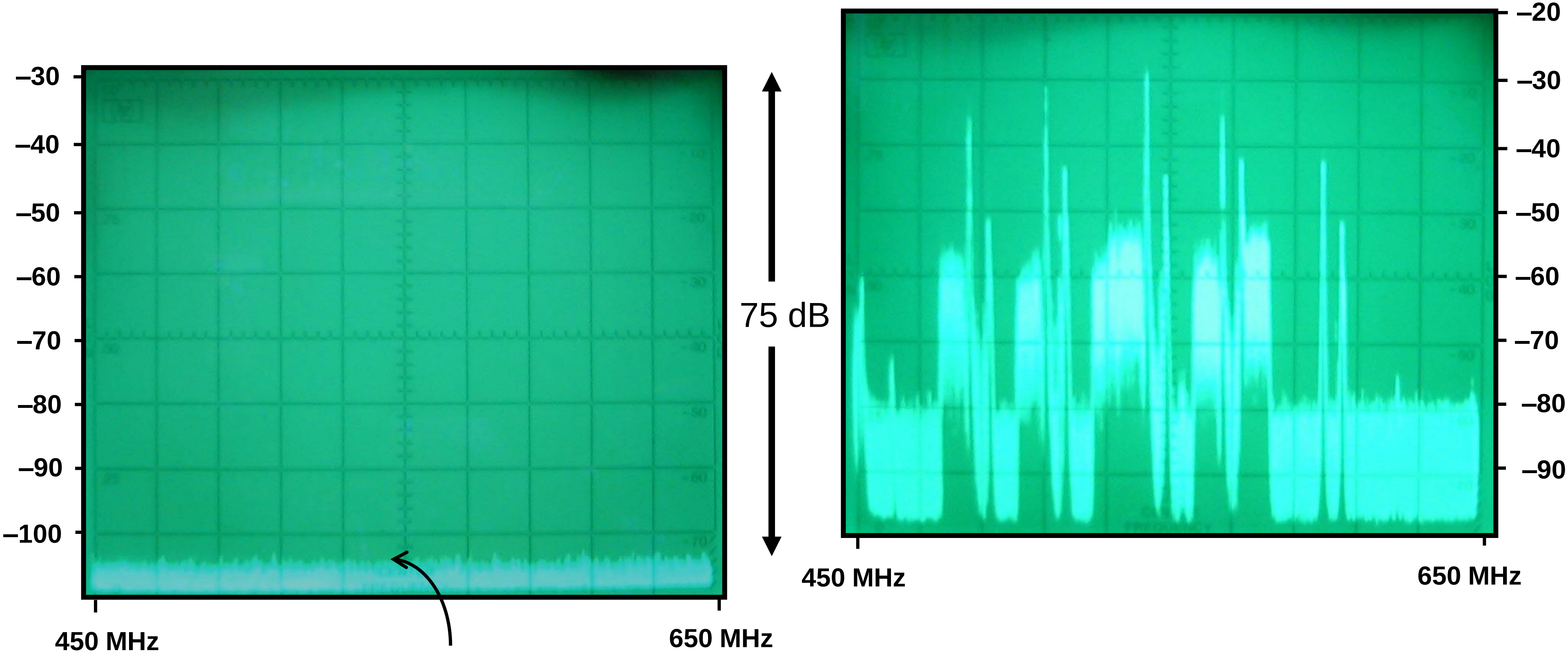
Noise level



$P_n = kT_0BF = –122$ dBm in $B = 50$ kHz

Noise levels in a passive radar receiver in FM radio band: (i) thermal noise in 50 kHz bandwidth corresponding to 5 dB receiver noise figure; top of screen = –50 dBm (ii) signal and noise levels measured from 10th floor of UCL in Central London on vertically-polarised dipole antenna; top of screen = –40 dBm.

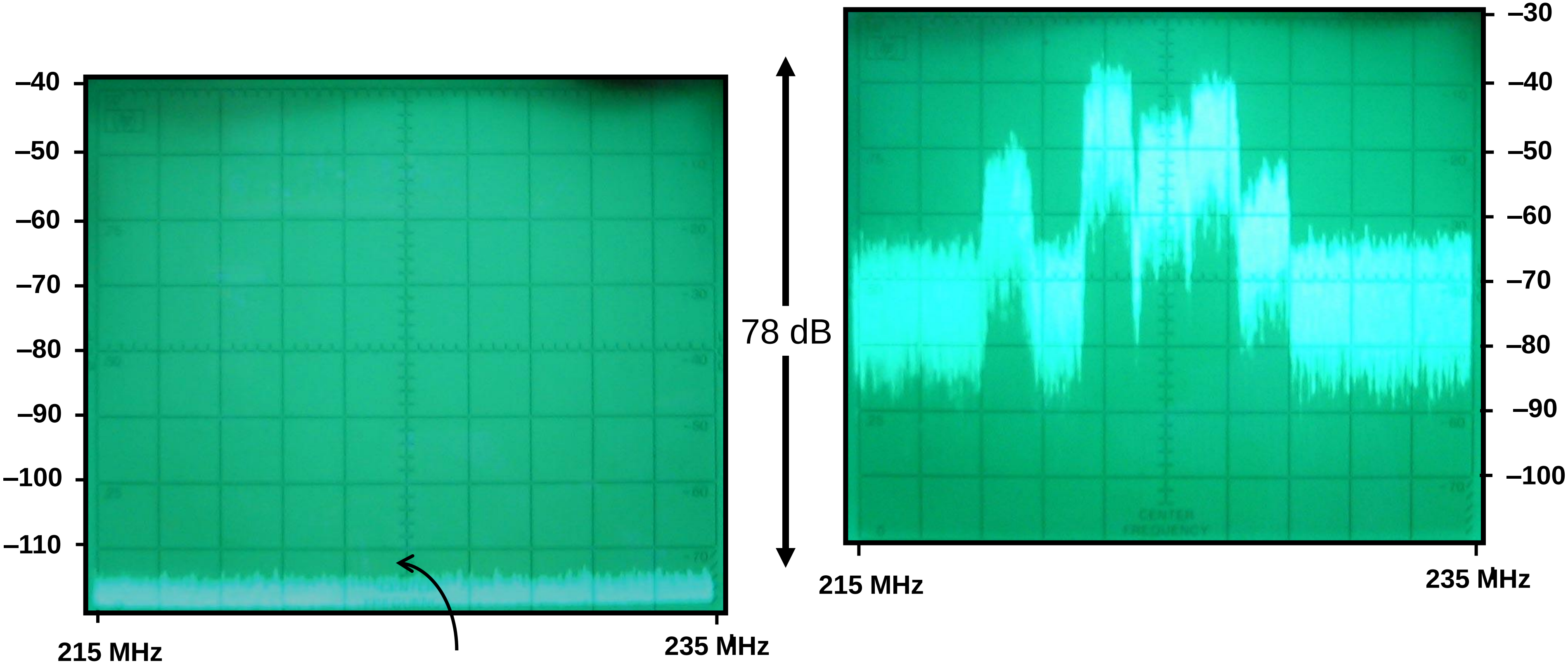
Noise level



$P_n = kT_0BF$ = –104 dBm in B = 3 MHz

Noise levels in a passive radar receiver in analogue TV band: (i) thermal noise in 3 MHz bandwidth corresponding to 5 dB receiver noise figure; top of screen = –40 dBm; (ii) signal and noise levels measured from 10th floor of UCL in Central London on horizontally-polarised 5-element Yagi antenna; top of screen = – 20 dBm

Noise level



$P_n = kT_0BF$ = –114 dBm in B = 300 kHz

Noise levels in a passive radar receiver in DAB radio band: (i) thermal noise in 300 kHz bandwidth corresponding to 5 dB receiver noise figure; top of screen = –40 dBm; (ii) signal and noise levels measured from 10th floor of UCL in Central London on vertically-polarised dipole antenna; top of screen = –30 dBm.

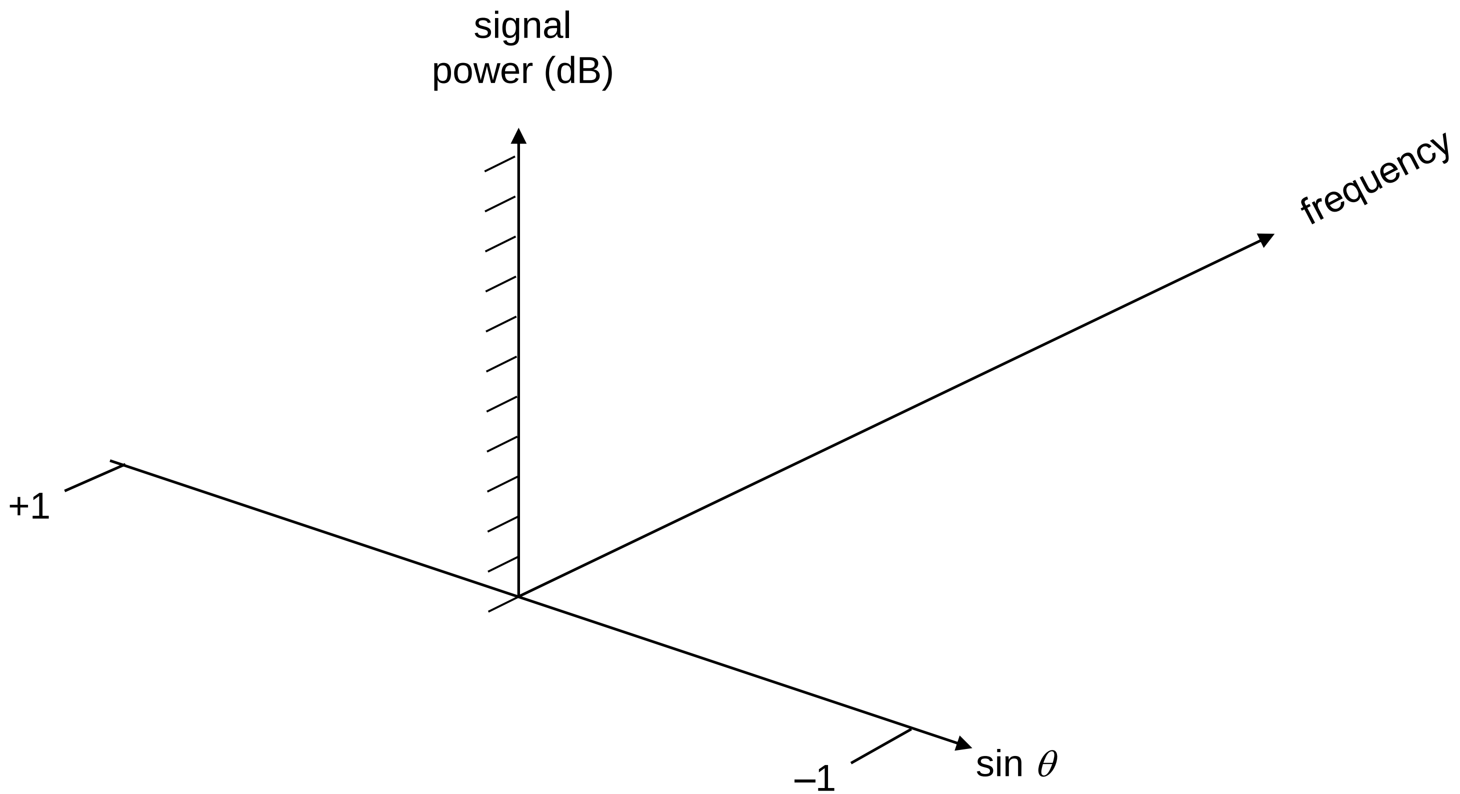
Noise and interference

We can view the noise and interference level as a two-dimensional function $P(\theta, f)$ of direction and frequency. To suppress the noise and interference we can use a combination of:

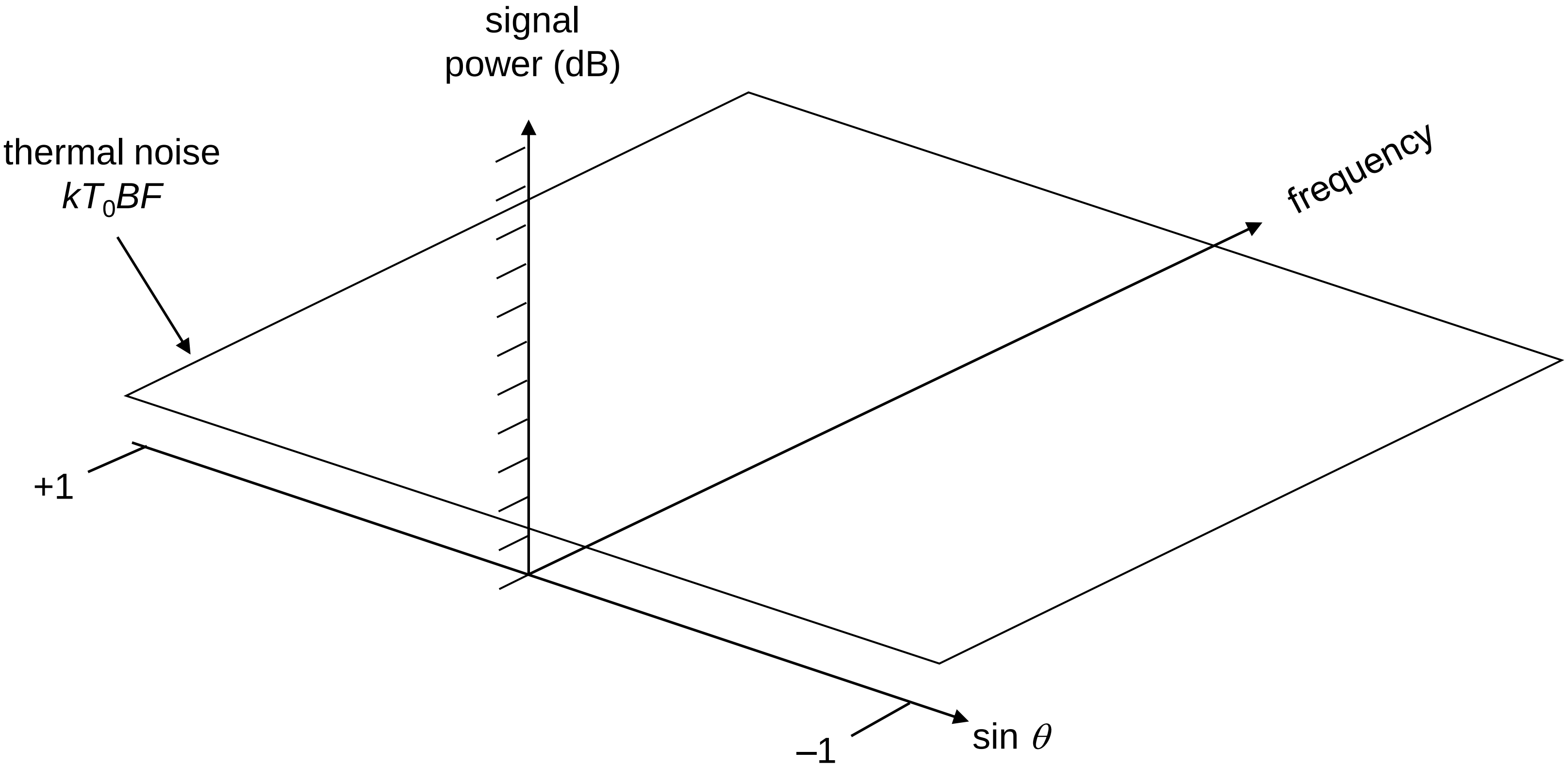
- physical shielding
- directional antennas
- null steering / adaptive beam forming
- Doppler (Fourier) processing

In order to reduce the dynamic range requirement on A-D converters it may be useful to precede the digitisation by analogue null steering.

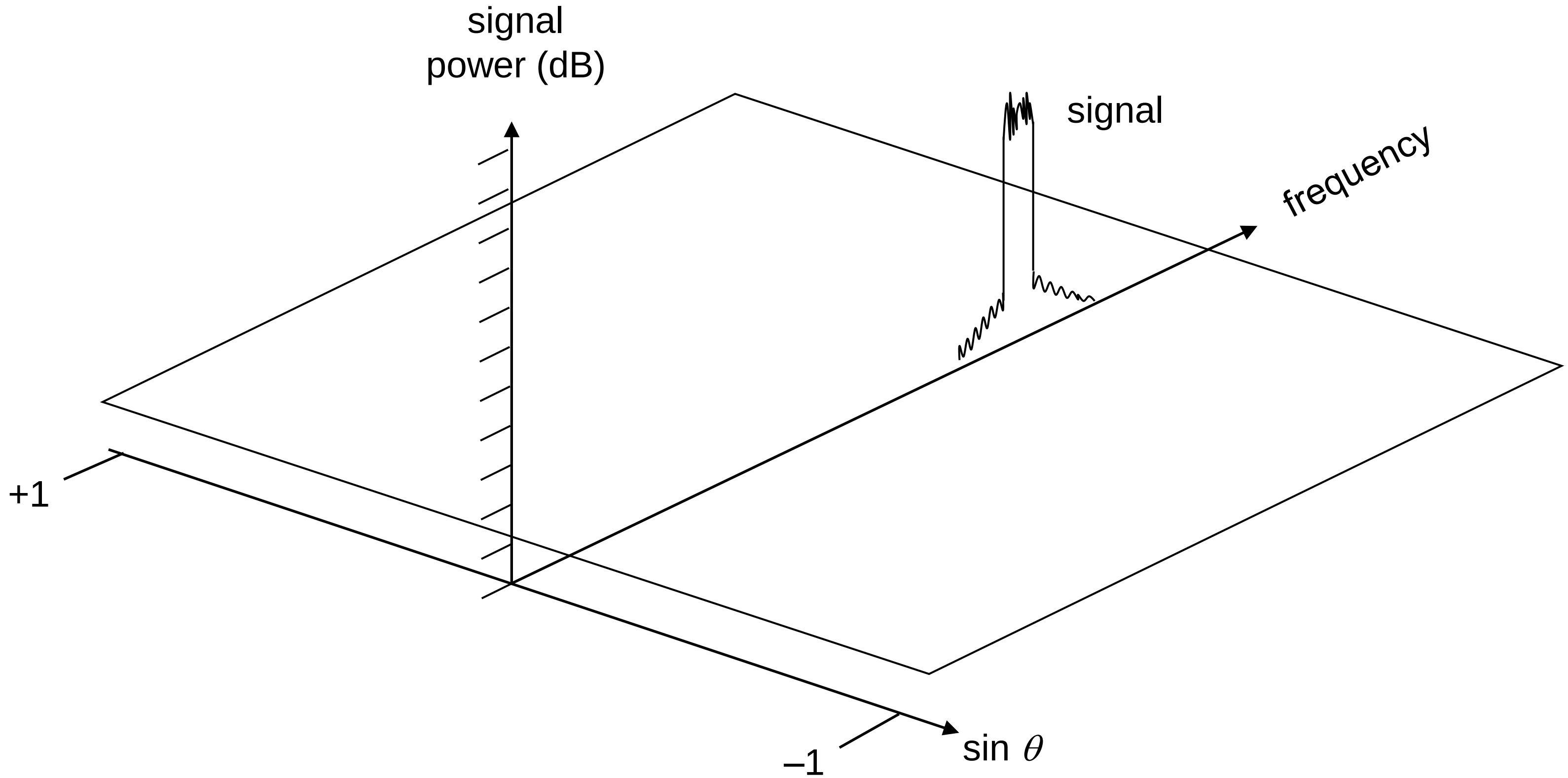
Noise and interference



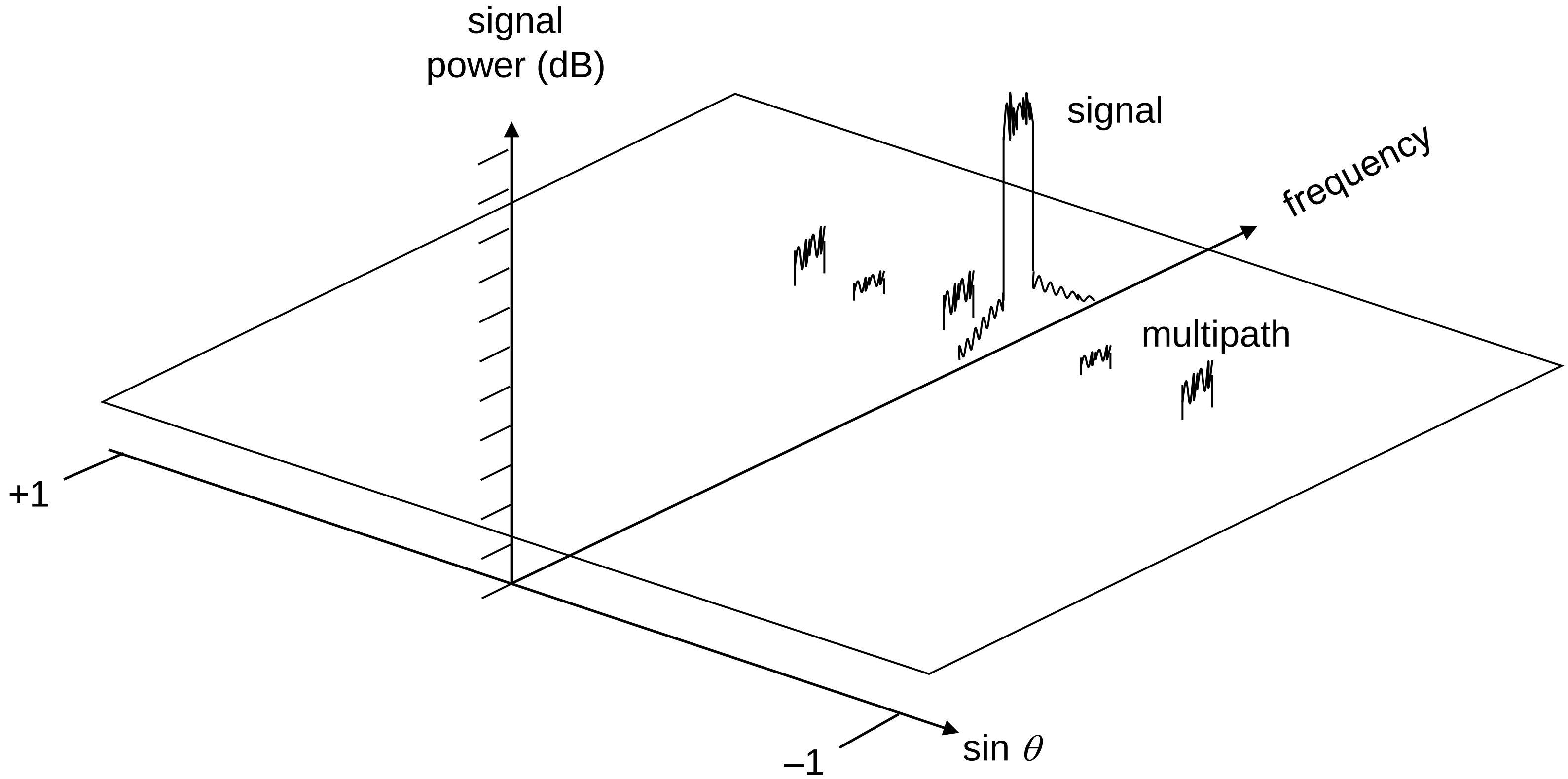
Noise and interference



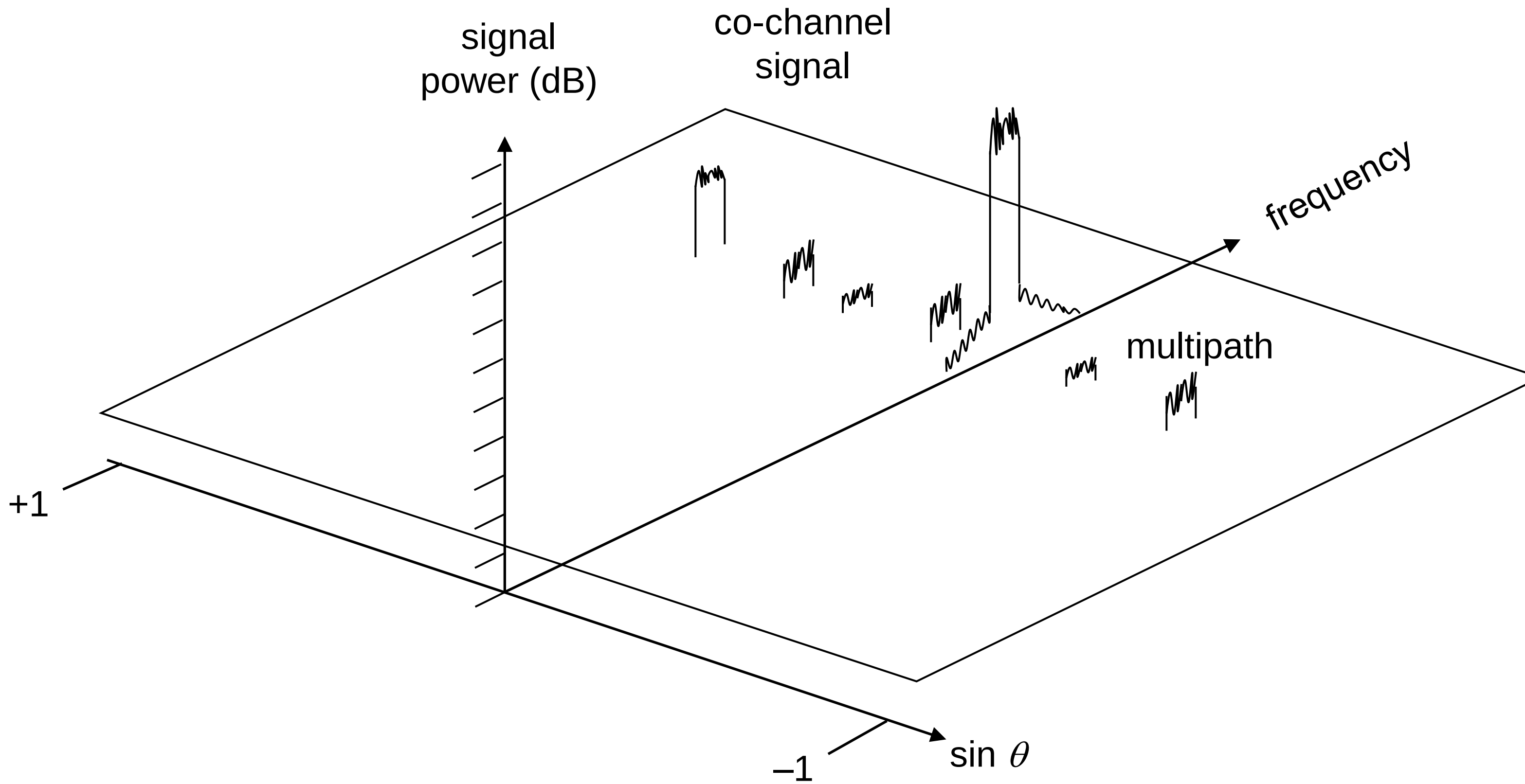
Noise and interference



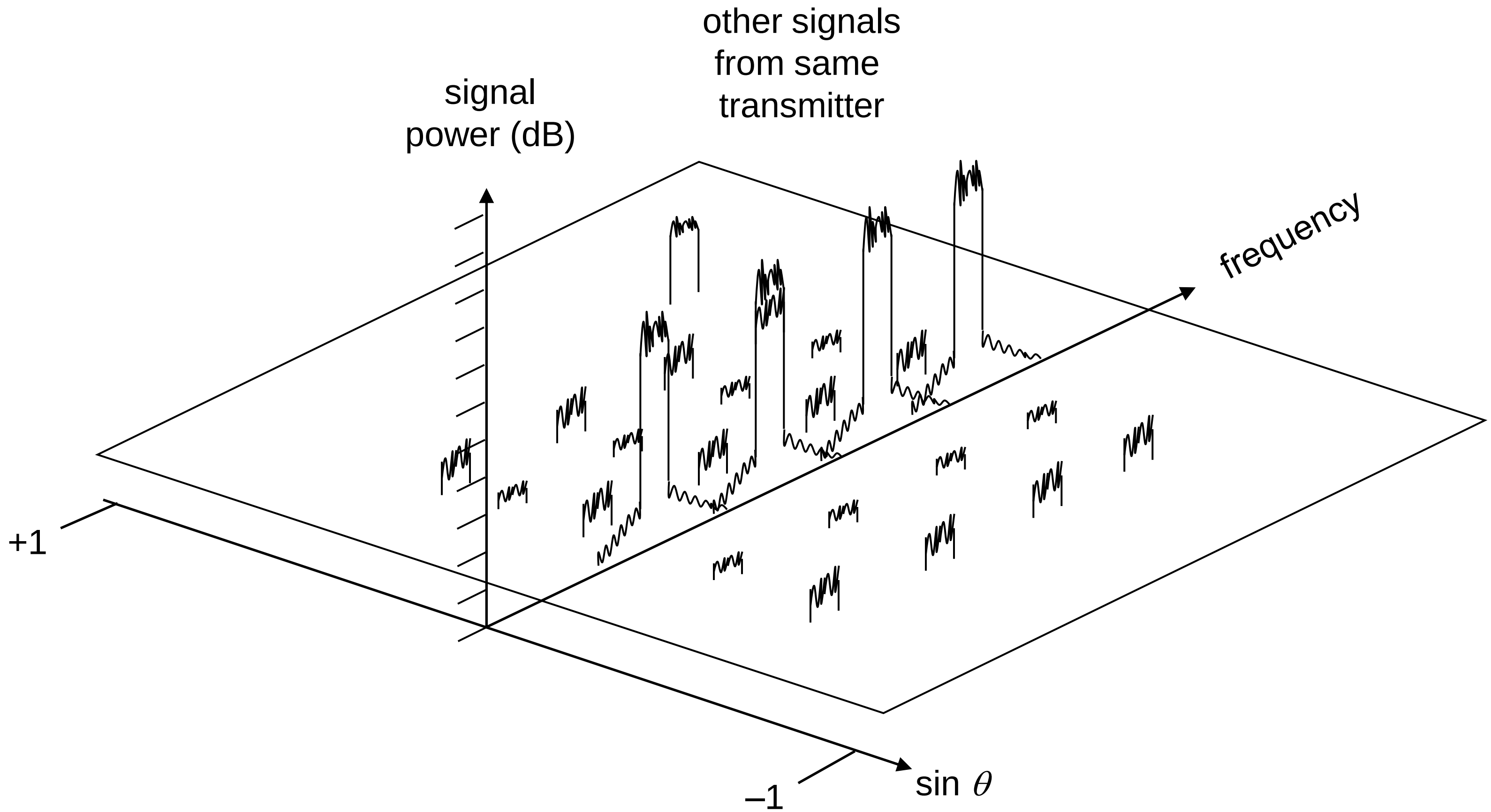
Noise and interference



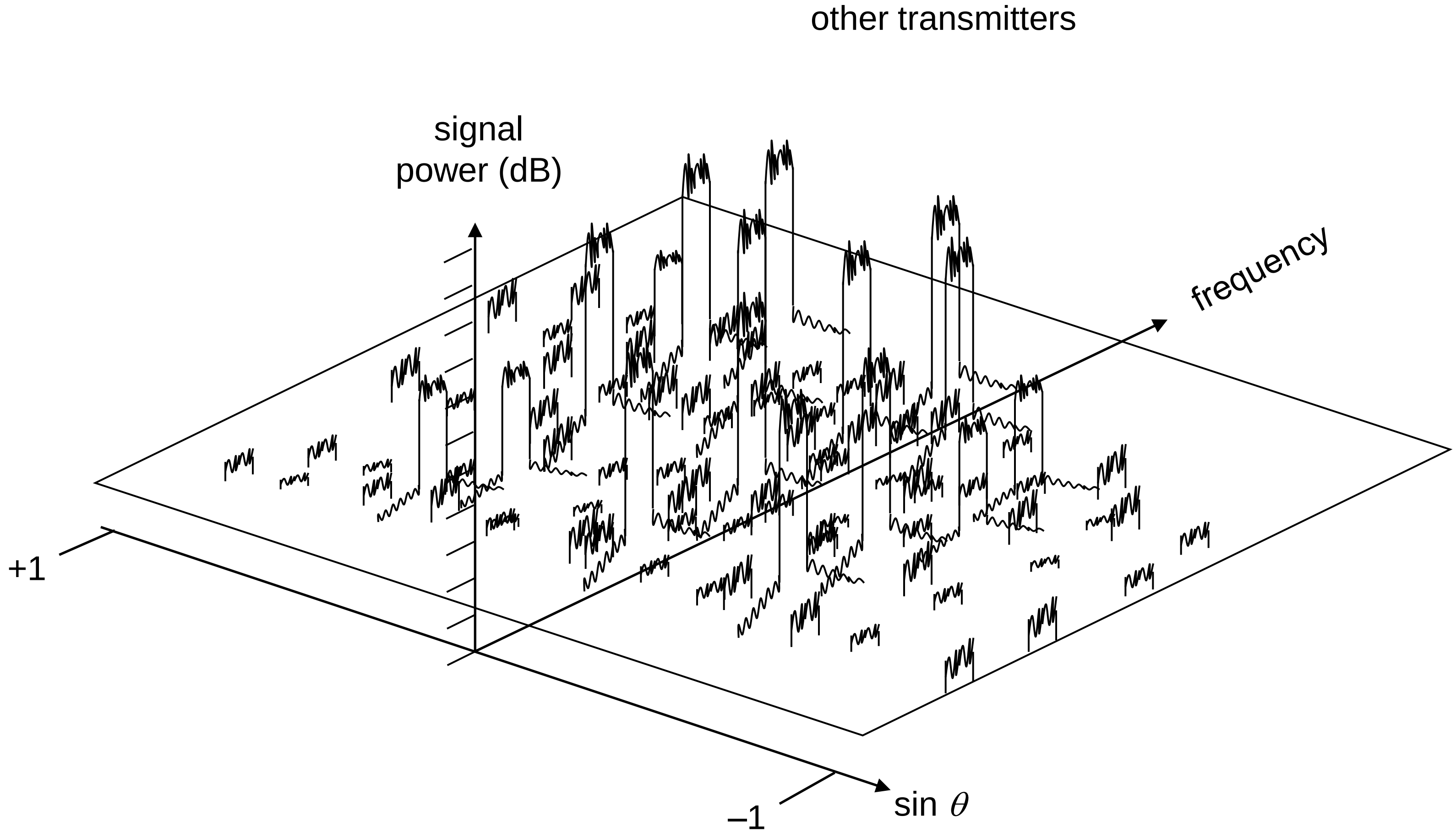
Noise and interference



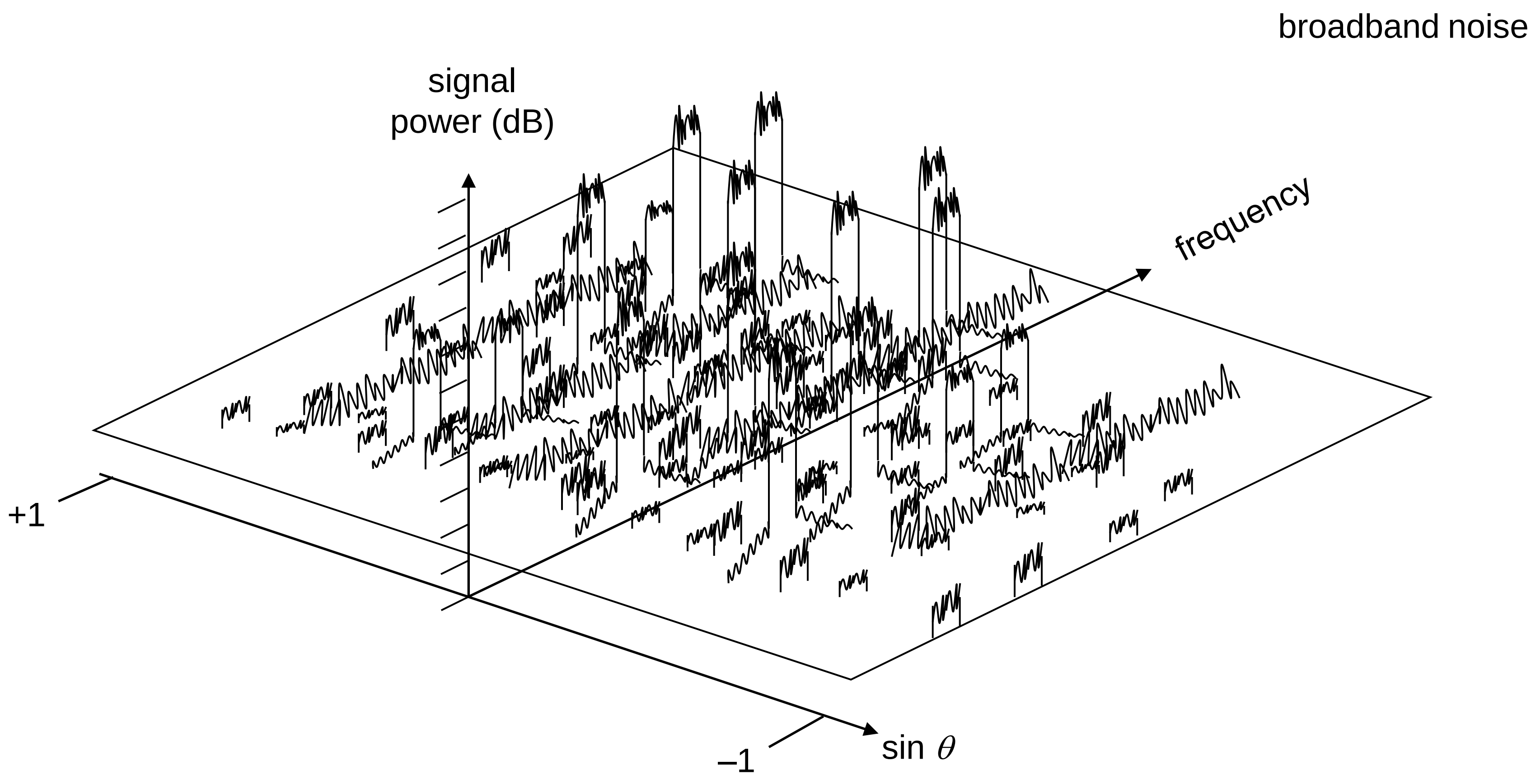
Noise and interference



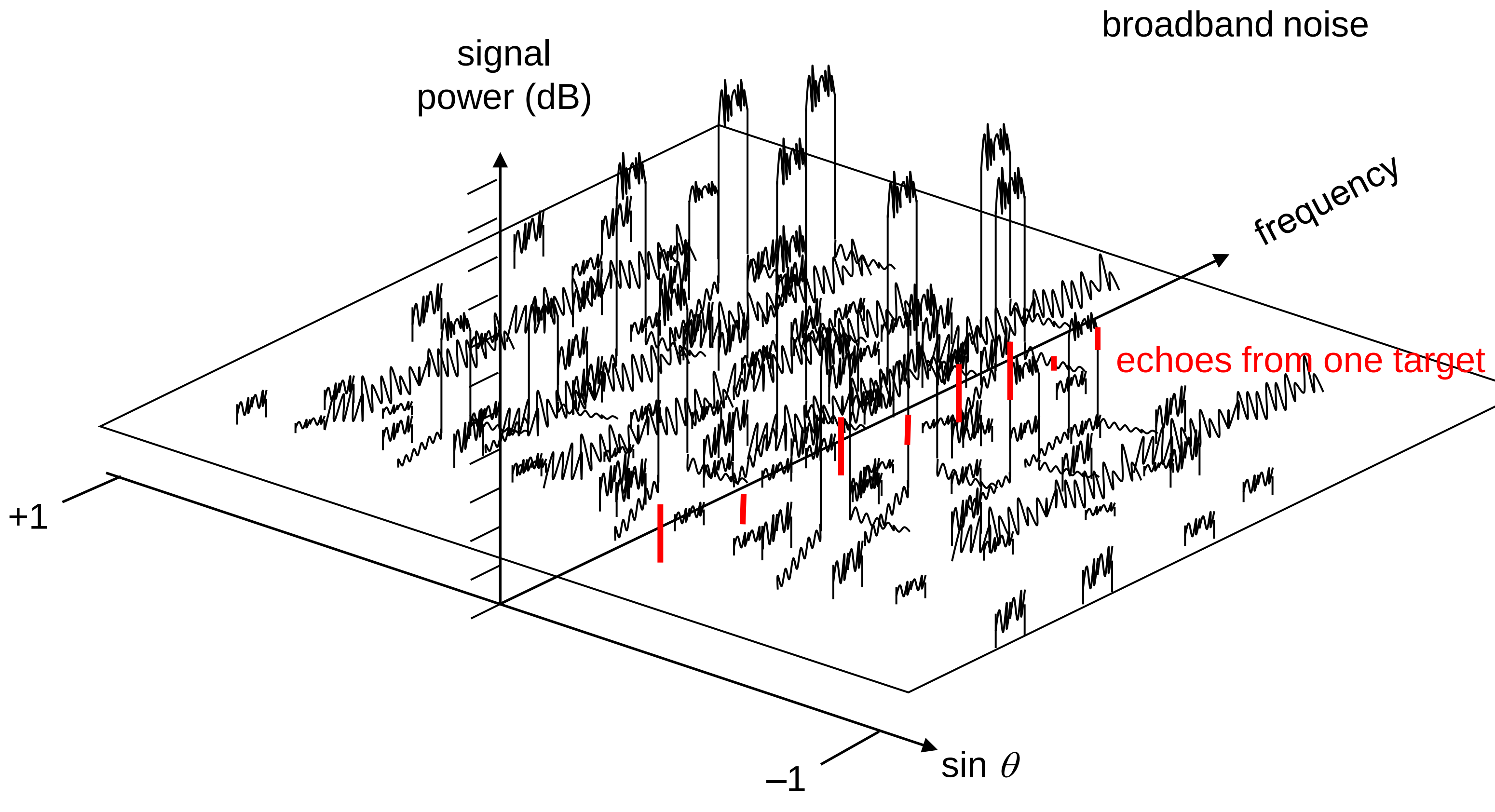
Noise and interference



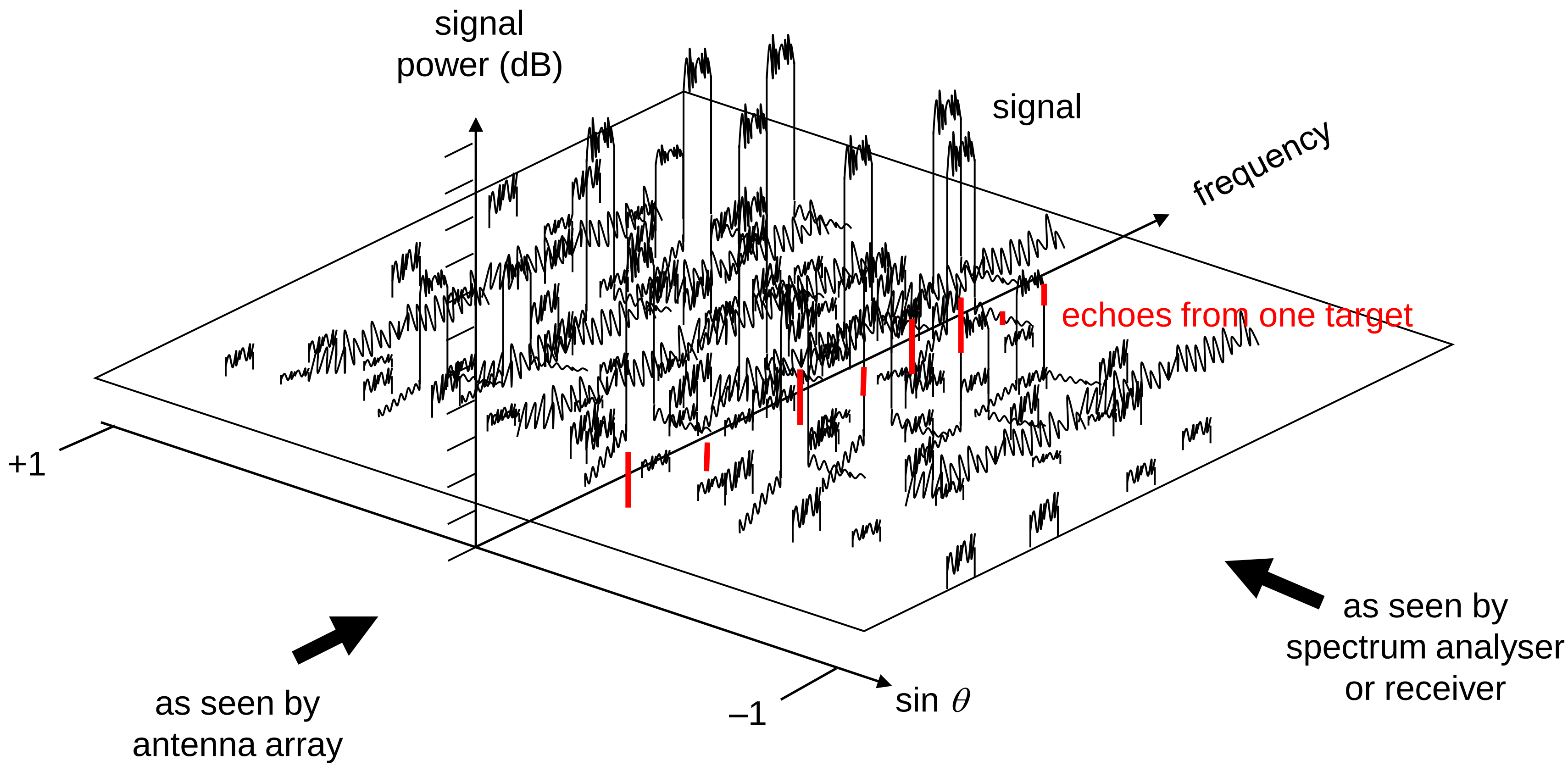
Noise and interference



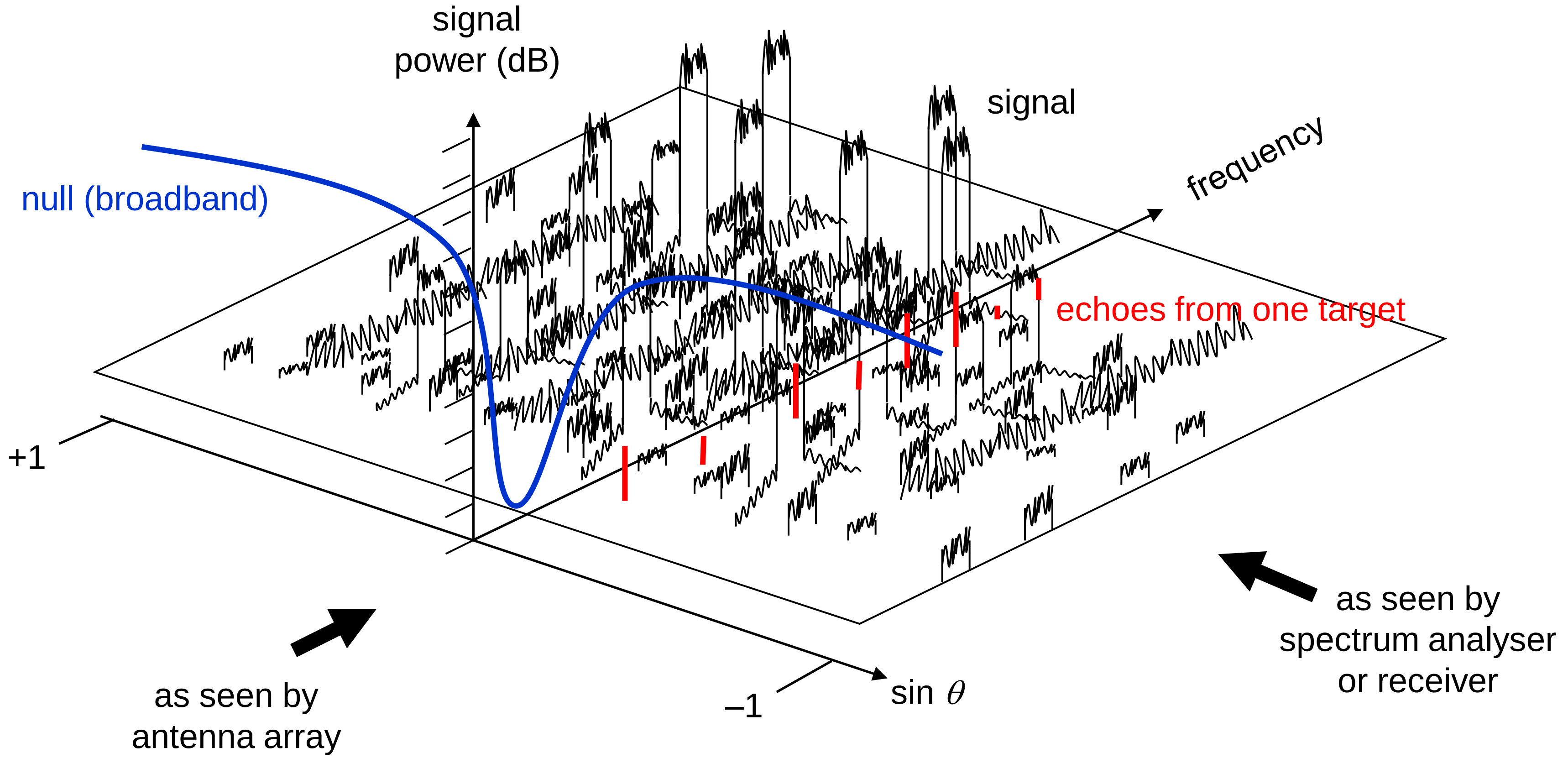
Noise and interference



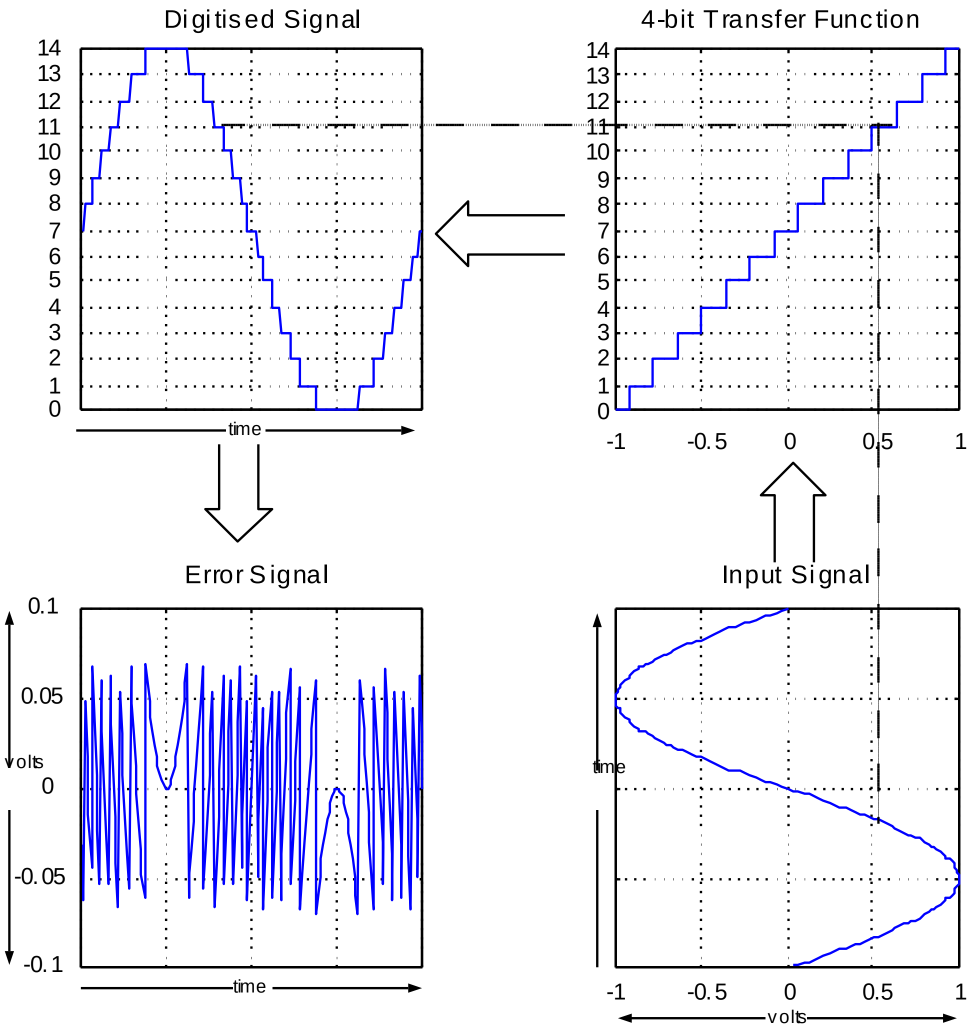
Noise and interference



Noise and interference

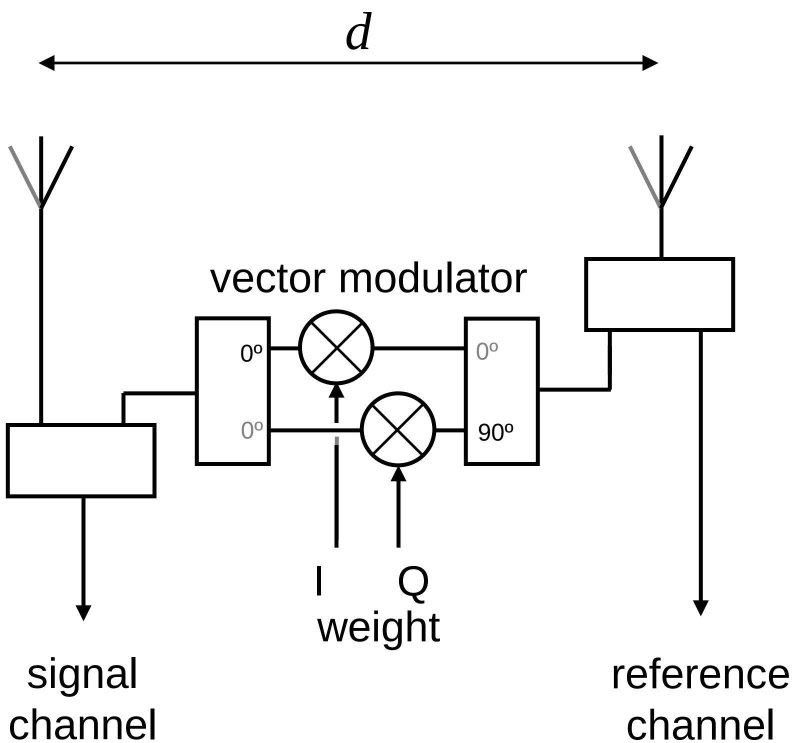


Quantisation noise



dynamic range = 1.76 + 6*n* dB, where *n* is number of bits

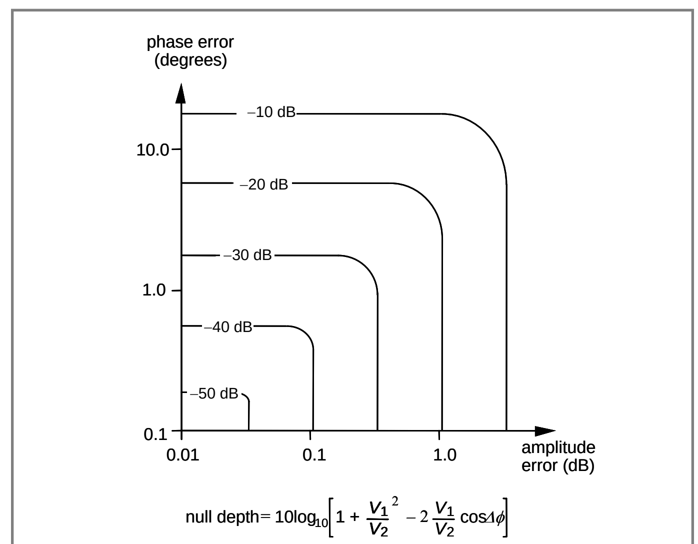
Null steering



$$\hat{W} = -\exp\left(-j\frac{2\pi d}{\lambda}\sin\theta_B\right)$$

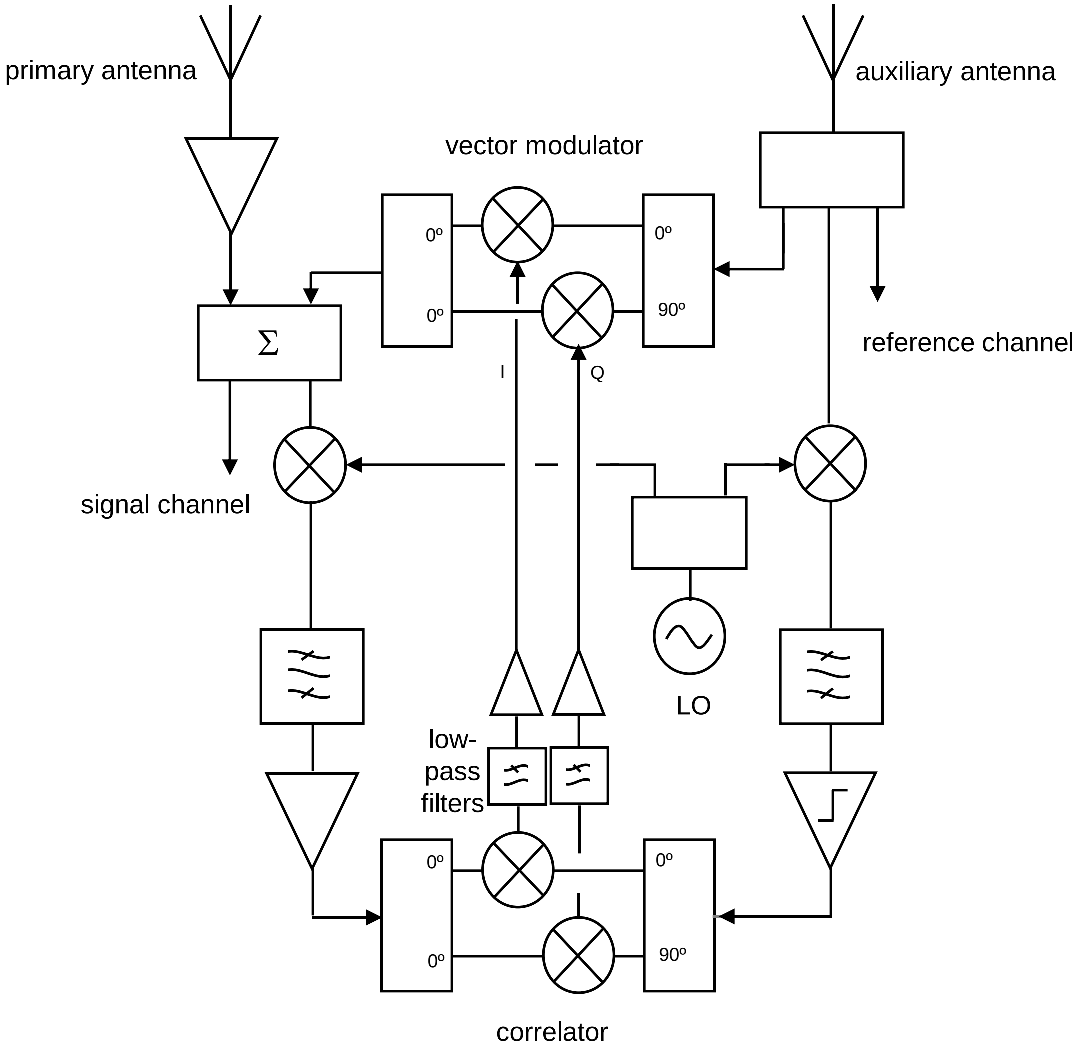
$$F(\theta) = 1 + \hat{W}\exp\left(j\frac{2\pi d}{\lambda}\sin\theta\right)$$
$$= 1 - \exp\left[j\frac{2\pi d}{\lambda}\left(\sin\theta - \sin\theta_B\right)\right]$$
$$= 2j\sin\left[\frac{\pi d}{\lambda}\left(\sin\theta - \sin\theta_B\right)\right]$$

cardioid pattern
with null at $\theta = \theta_B$



null depth vs weight accuracy

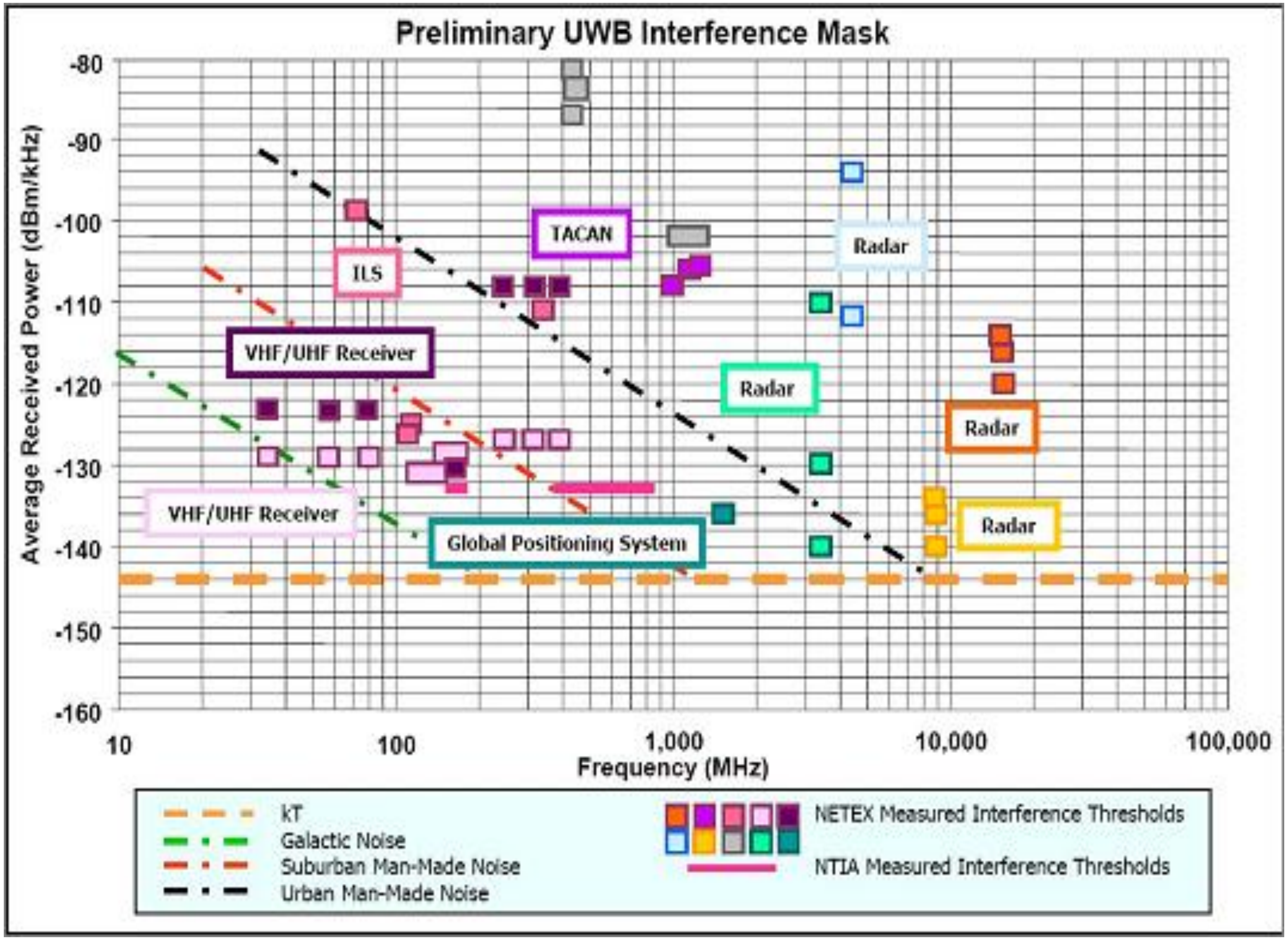
Null steering – Howells-Applebaum correlation loop



- Can use a circular antenna array to give full 360º coverage, using phase modes as inputs to processor rather than element signals
- Readily extended to more than one degree of freedom

Griffiths, H.D., 'A four-element VHF adaptive array processor', *Proc. 2nd IEE Intl. Conference on Antennas and Propagation*, York, IEE Conf. Publ. No. 195 Part I, pp185–189, 13–16 April 1981.

Noise and interference



Passive radar: technical problems

Potential way out: contemporaneous operation of active and passive radar.

- Technical problem for passive radar:

Target detection notwithstanding “e.m. clamour” !
“Perceive a whisper in a cocktail party”!

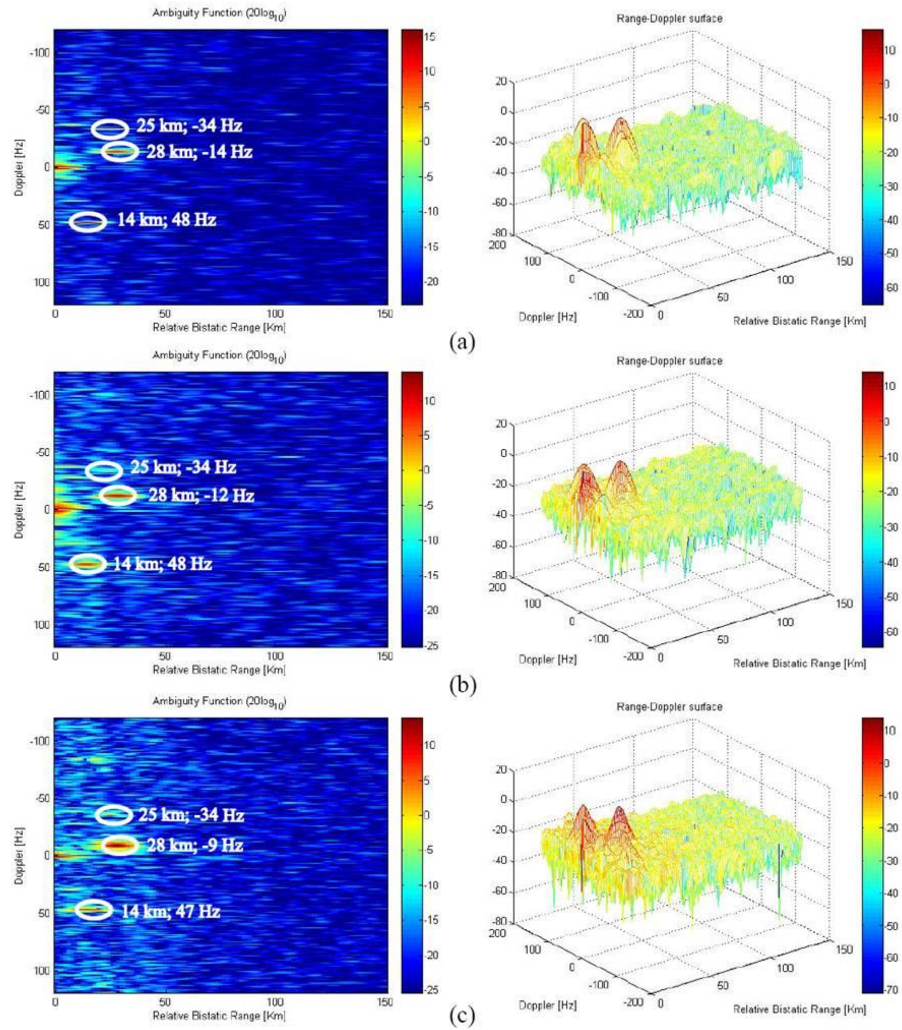
?

STOP

Direct Signal Suppression

Here we explore one well-known algorithm for Direct Signal Suppression – due to Colone et al.

The approach of may be understood by visualizing the signal and multipath environment in the range-Doppler plane. It is assumed that a clean reference version of the direct signal is obtained via a separate antenna and receiver which is free of multipath.



Colone, F.; Cardinali, R.; Lombardo, P. Cancellation of clutter and multipath in passive radar using a sequential approach, *IEEE Radar Conference*, Verona (NY), USA, 393-399, 24–27 April 2006.