# Windowing and Spectral Leakage

This rectangular window will cause no spectral leakage because it just happens to capture exactly one cycle of the pure sinusoidal signal under analysis. However, this rectangular window will cause terrible leakage because it captured exactly 1.5 cycles of the same signal. The source of the spectral leakage is the sharp discontinuity introduced at the window edges due to the assumption of periodic extension. For most real information-bearing signals its not possible to find a rectangular window length which will capture an integer number of cycles of all of the sinusoidal components so in practice a useful compromise window is a 'bell-shaped' or Gaussian one e.g. a Hamming or Hanning window. Although these bell-shaped windows do distort the signal which affects the analysis, they generally reduce spectral leakage by attenuating any sharp discontinuities at the window edges.
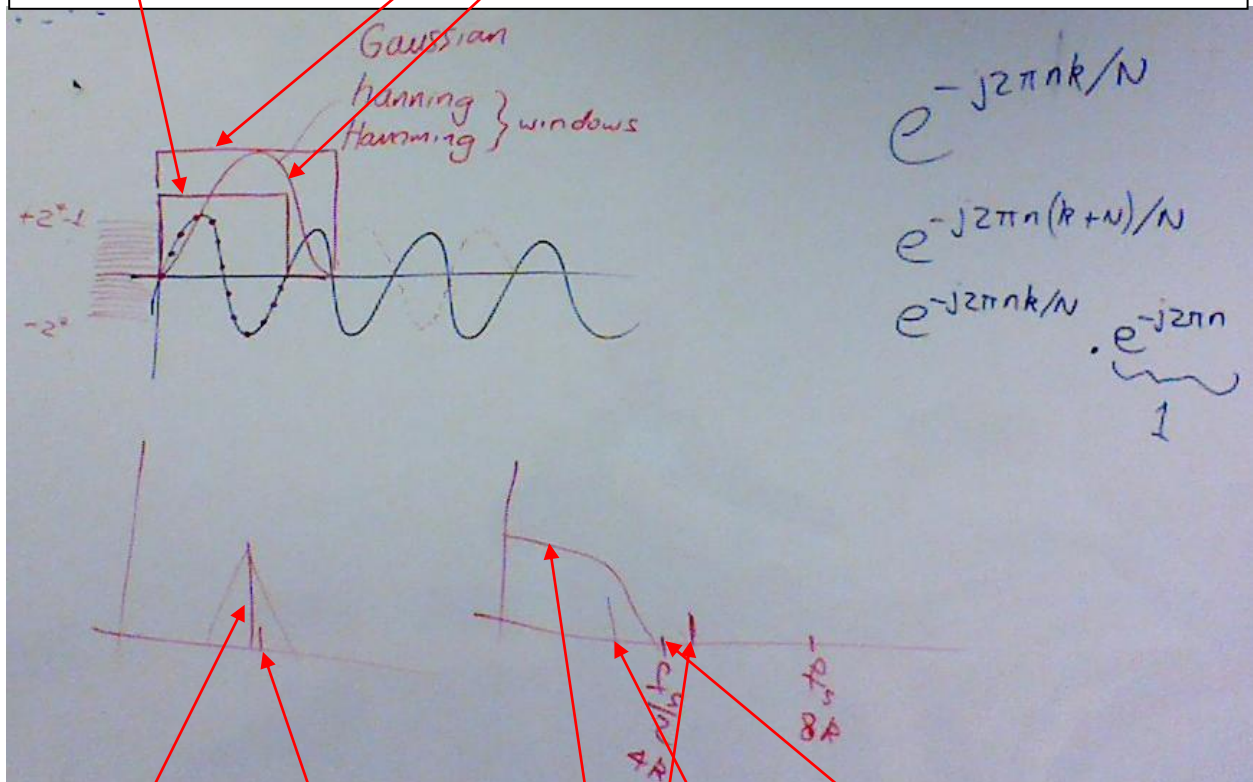
Spectral leakage would make it very difficult to detect this low energy component close to this bigger one

An anti-alias lowpass filter is used to remove all frequency components above $f_s/2$ (the Nyquist frequency = half the sampling frequency). If this isn't done before sampling then any frequency components above Nyquist freq will mirror back about the Nyquist freq interfering with real components below Nyquist and cause alias.