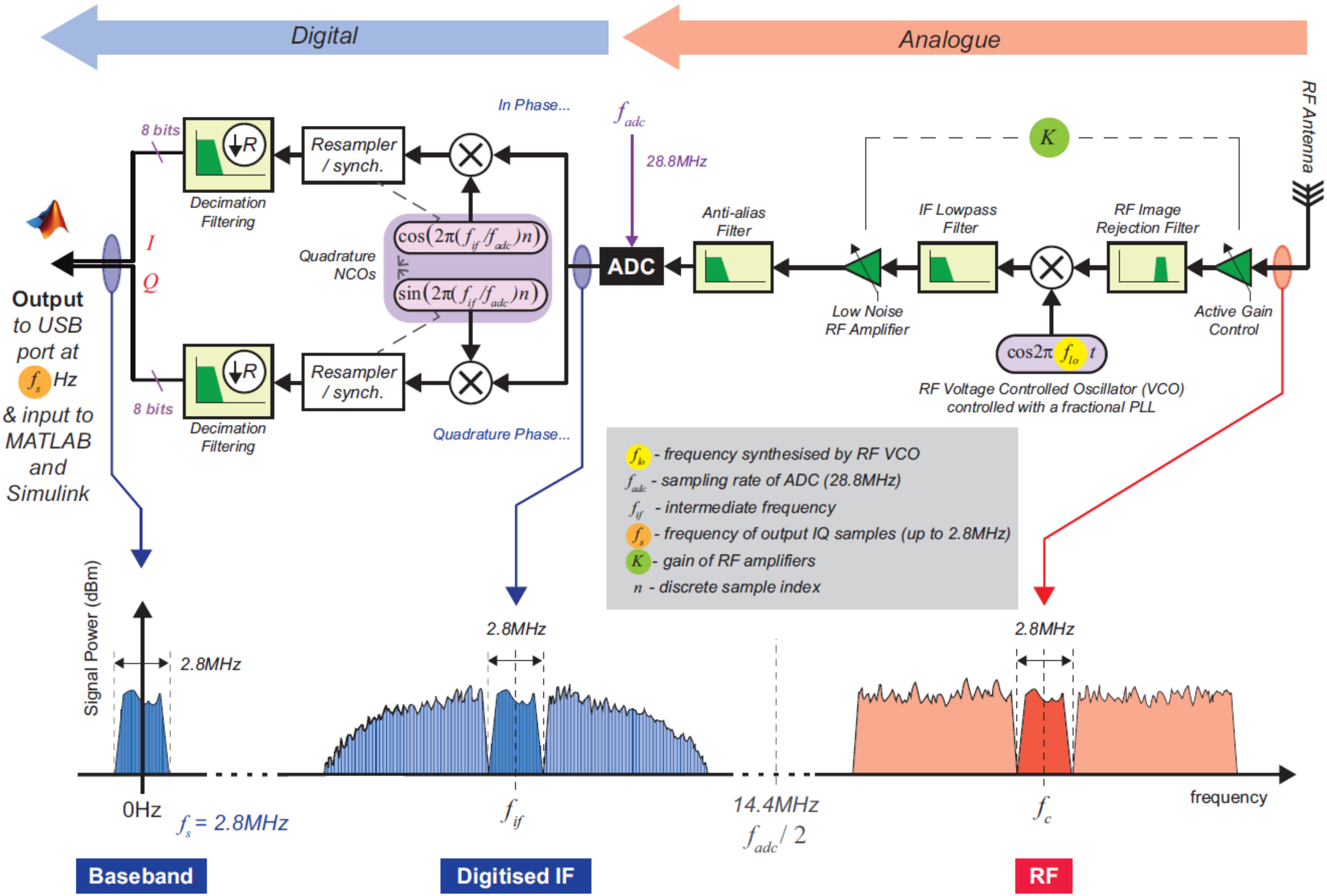
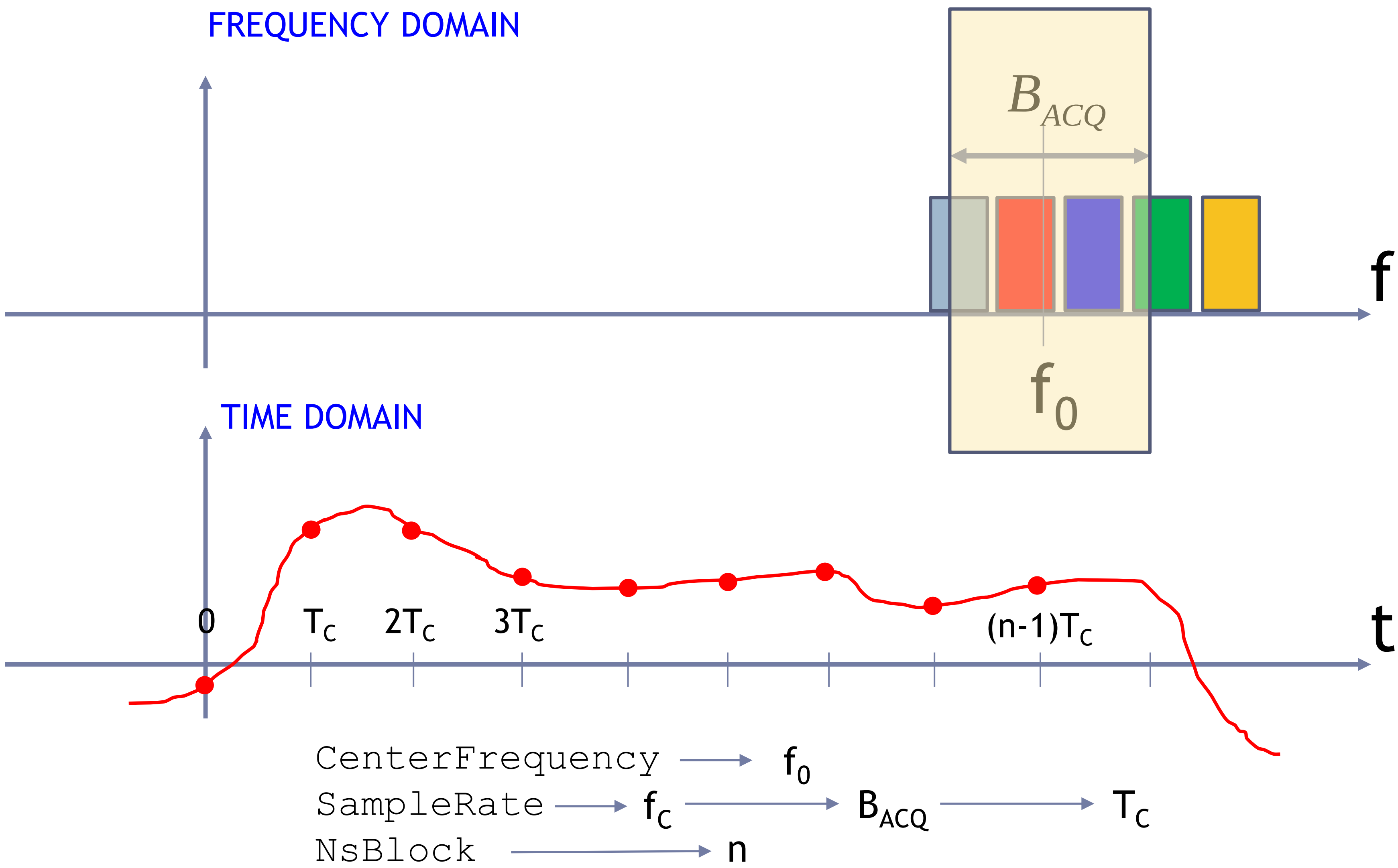
LAB #3.2 – SPECTRUM ANALYZER

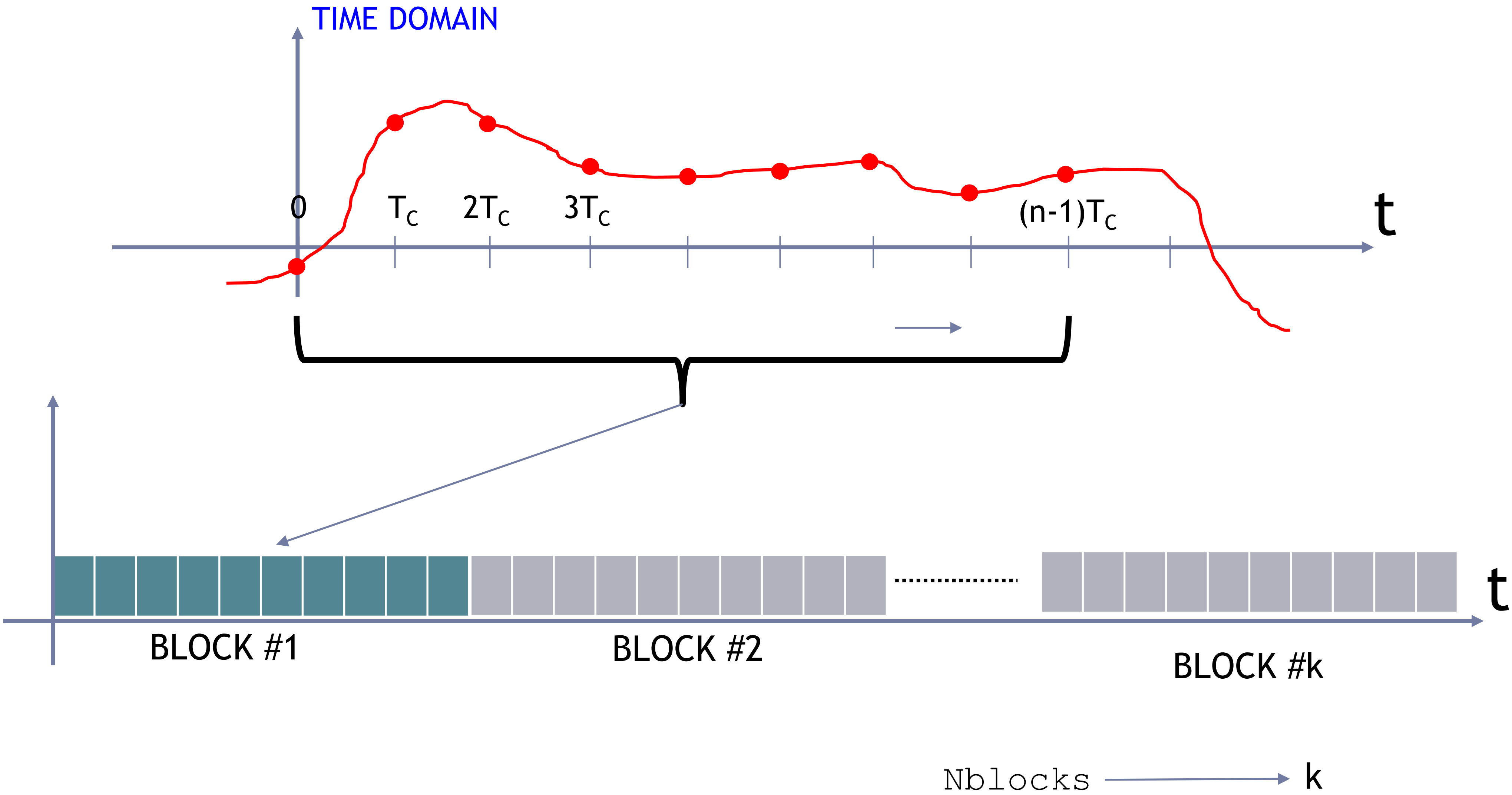
RTL-SDR: how it works



SIGNAL ACQUISITION



SIGNAL ACQUISITION



SIGNAL TYPE

The SDR receiver down-shift a pass-band signal and it acquires the two QUADRATURES of the signal

The resulting sample vector contains a COMPLEX SIGNAL

$$x_I(t)+jx_Q(t)$$

MATLAB CODE

```
CenterFrequency=92.1e6;
SampleRate=1e6;
NsBlock=1024;

Nblocks=1000;
```

GENERAL PARAMETERS

```
hRadio = comm.SDRRTLReceiver('CenterFrequency', CenterFrequency, ...
   'SampleRate', SampleRate, ...
   'EnableTunerAGC', true, ...
   'SamplesPerFrame', NsBlock, ...
   'OutputDataType', 'single');
```

SETUP SDR RECEIVER

```
if ~isempty(sdrinfo(hRadio.RadioAddress))
```

CHECK SDR

```
    x_saved=NaN*ones(Nblocks*NsBlock,1);
```

INITIALIZE OUTPUT SIGNAL

ACQISITION LOOP

```
    for Counter=1:Nblocks

        [x, len,lost(Counter)] = step(hRadio);
```

SIGNAL ACQUISITION

```
        x_saved((Counter-1)*NsBlock+1:(Counter-1)*NsBlock+NsBlock)=x;
```

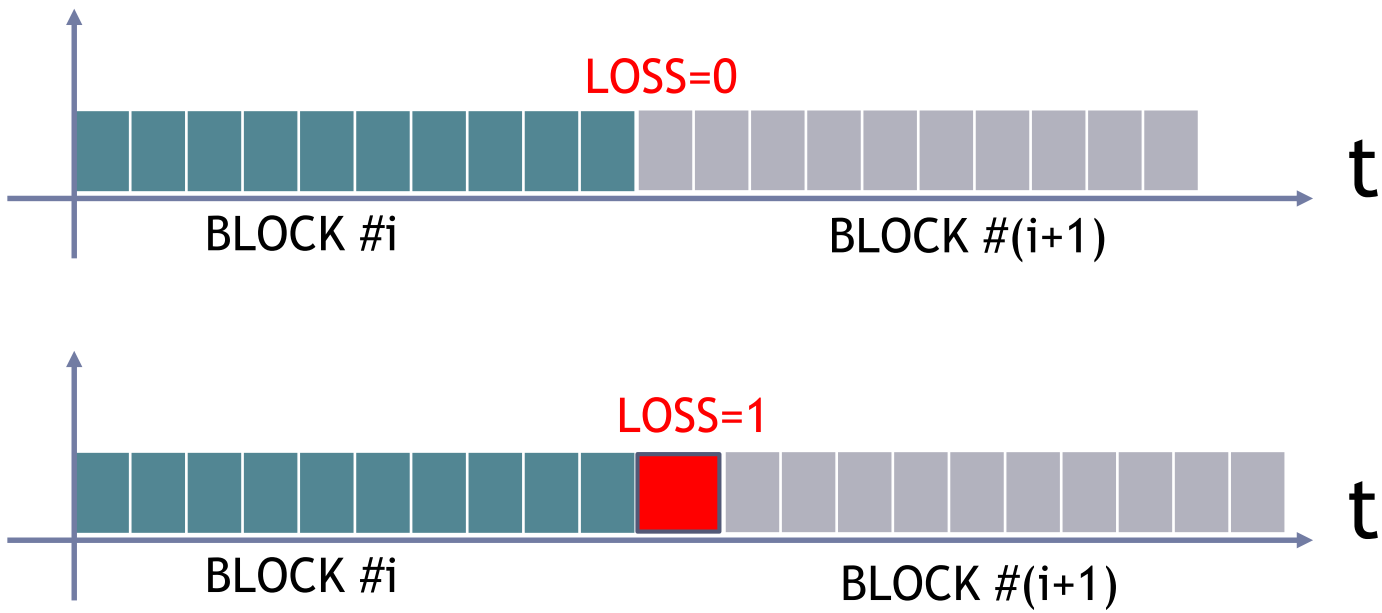
SIGNAL STORAGE

```
    end

else
    warning('SDR Device not connected')
end
release(hRadio);
```

LOSS OF SIGNAL

If blocks are not contiguous the LOSS flag is set to true



For spectral evaluation, even when averaging over multiple blocks, LOSS of signal continuity is not a problem

SPECTRUM EVALUATION

We can obtain the PSD, power spectral density, using Fourier transform: fft in matlab

We can apply the Fourier transform over the whole vector of samples

Let’s set the frequency axis: which is our frequency resolution?

```
Df=SampleRate(NsBlock*Nblocks)
f=[SampleRate/2:Df: SampleRate/2-Df];
```

NUMBER OF SAMPLE ACQUIRED

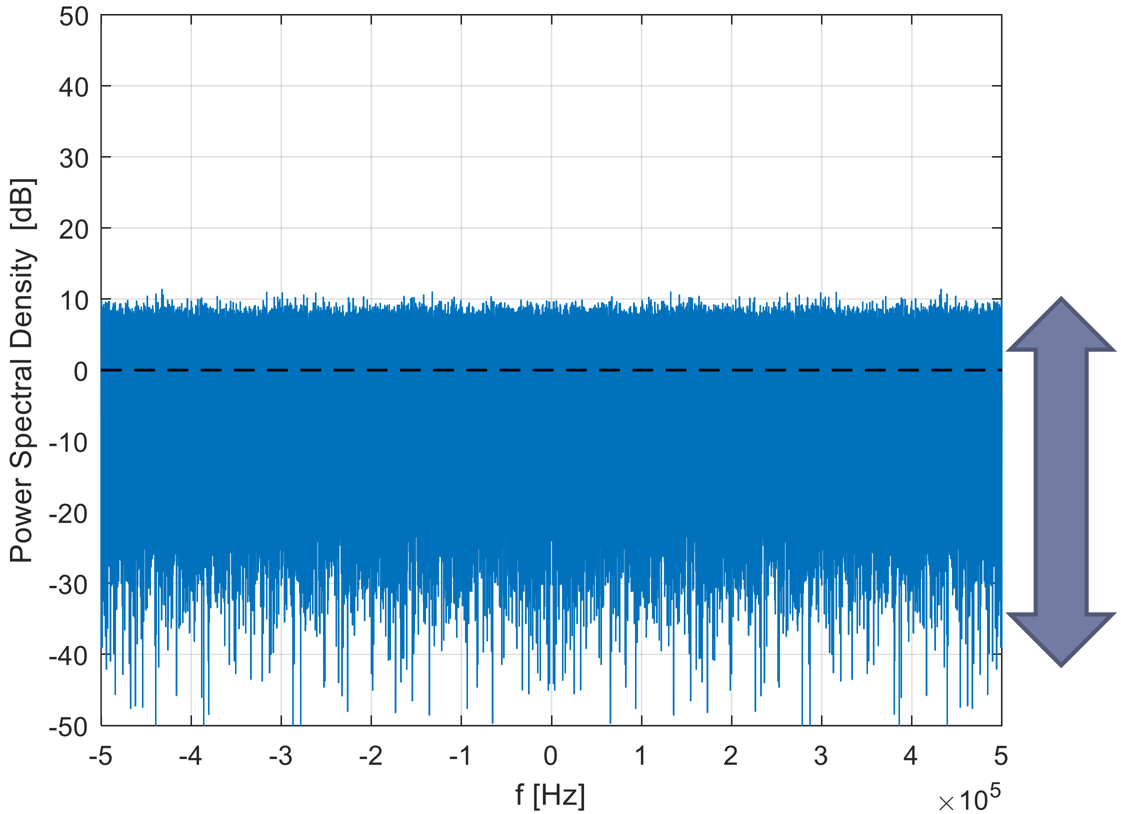
If Df is too small (because of an high number of samples), the PSD estimation is not very good

SPECTRUM EVALUATION: EXAMPLE

White Gaussian Noise – B_{SIM} = 1 MHz – $N_{samples}$=1e6

Level expected: 0 dB (black dashed line)

FFT Estimation 1e6 samples: blue line

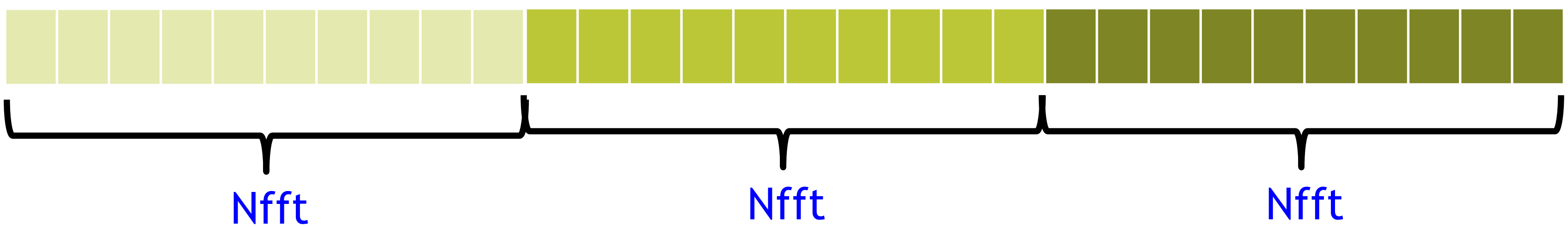


High resolution: 1 Hz
but
High uncertainity

SPECTRUM AVERAGING

We can improve PSD estimation by averaging over several fft evaluation

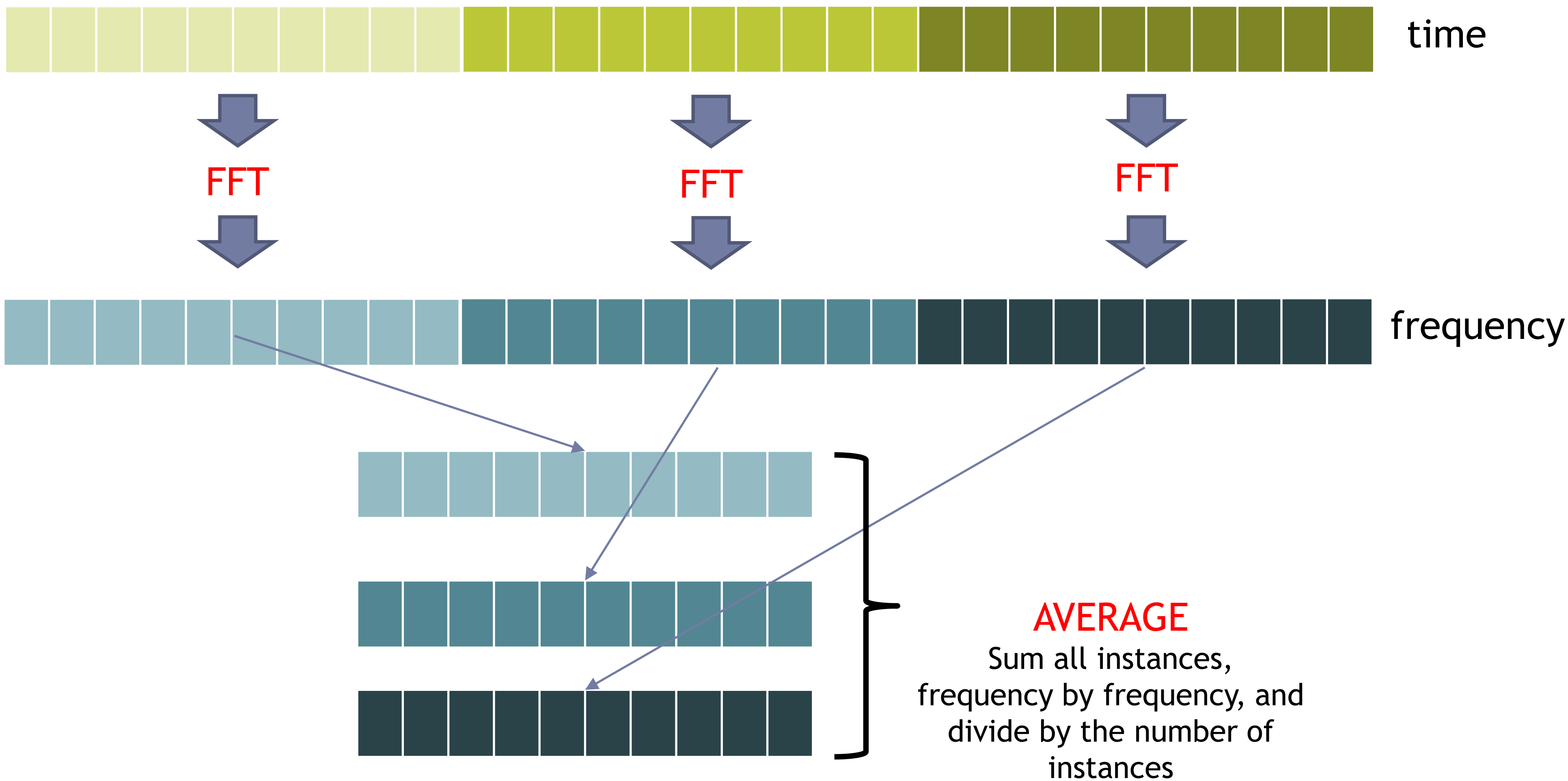
We divide the whole sample vector in short chunk (Nfft samples)




```
f=[SampleRate/2:Df: SampleRate/2-Df];
Df=SampleRate/Nfft
```

Being Nfft smaller than the total number of samples we loos resolution, but we can take advantage of averaging multiple PSD estimation

SPECTRUM AVERAGING



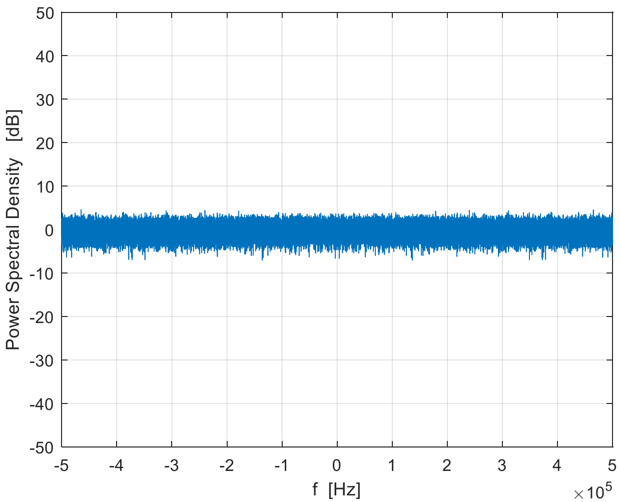
A simple choice fo Nfft could be the acquisition block length (NsBlock)

SPECTRUM AVERAGING: EXAMPLE

White Gaussian Noise – B_{SIM} = 1 MHz – $N_{samples}$=1e6

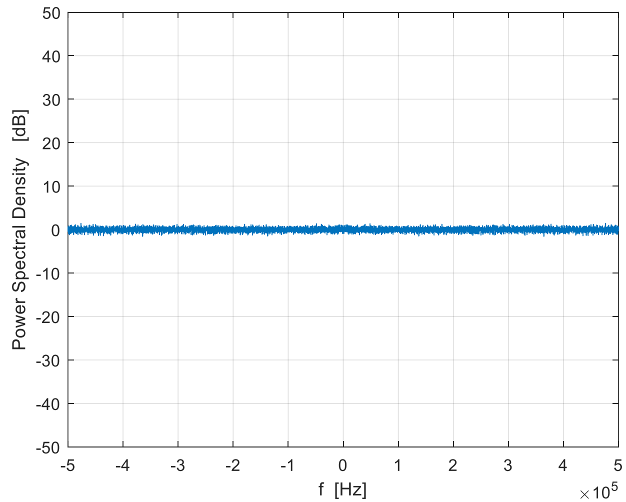
Level expected: 0 dB (black dashed line)

FFT Estimation over
1e5 samples
(Average over 10 blocks)



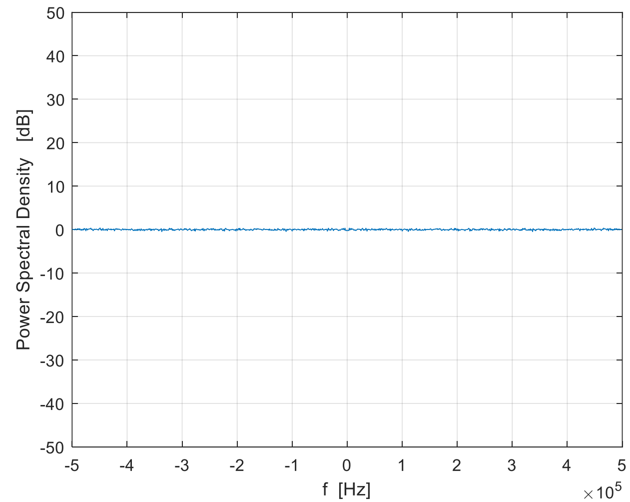
Resolution: 10 Hz

FFT Estimation over
1e4 samples
(Average over 100 blocks)



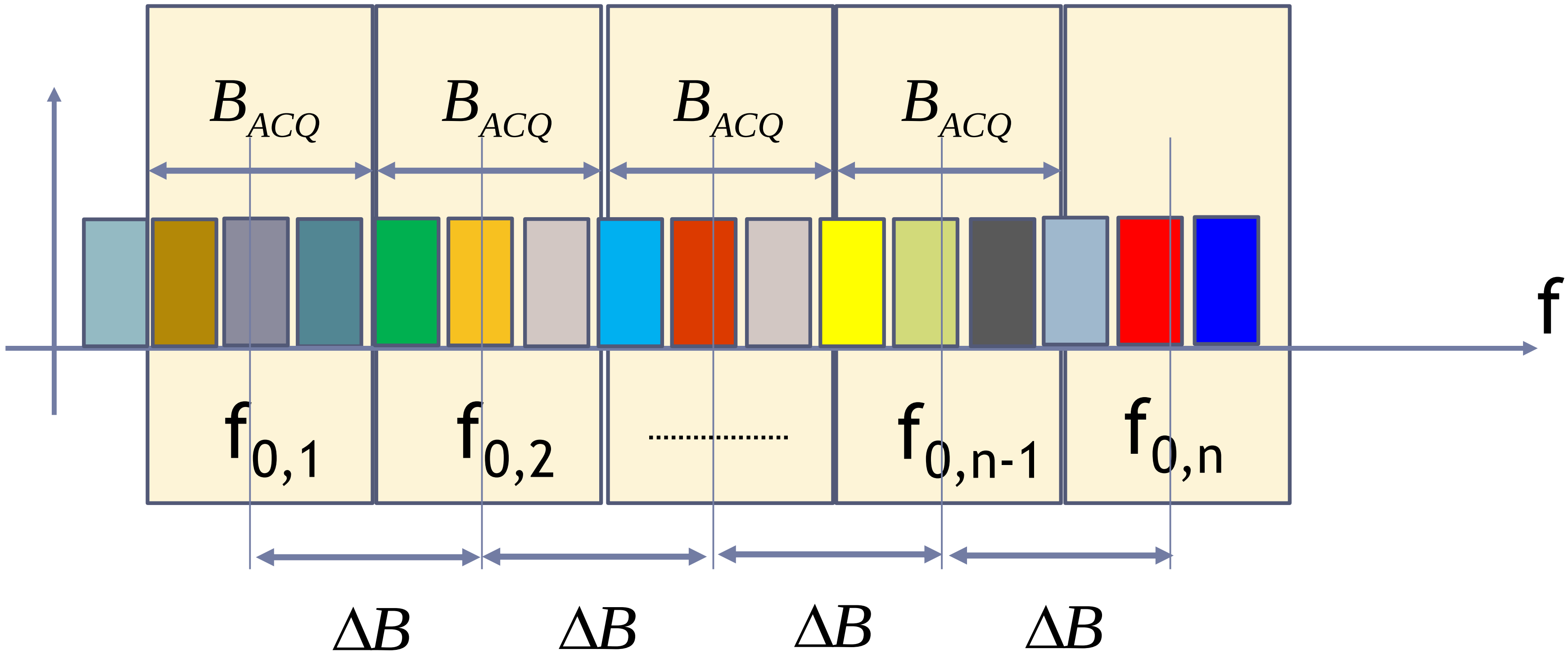
Resolution: 100 Hz

FFT Estimation over
1e3 samples
(Average over 1000 blocks)



Resolution: 1000 Hz

FREQUENCY SWEEPING



The simplest choice to completely capture a given range of frequency is to have $\Delta B = B_{ACQ}$

SDR INSTALLATION

1. Read instructions can be found at

http://it.mathworks.com/help/supportpkg/rtlsdrradio/ug/support-package-hardware-setup.html

2. Launch `supportPackageInstaller`

3. Look for the “Communications System Toolbox Support Package for RTL-SDR Radio” (filter using SDR)

4. Follow CAREFULLY instructions